DEMPSTER'S PATENT CANVAS.

In such a country as Great Britain, any real and substantial improvement in an article of prime necessity, one at first sight should imagine, would meet immediate and universal patronage. It is, however, a well known fact, that no new invention, let it be as excellent as possible, will, or can be, suddenly adopted. People must first be convinced, by actual experience, that it really possesses the merits attributed to it. This is an obstacle that every one, who attempts to introduce any improvement, must lay his account with. It, besides, not unfrequently happens, when the invention is of such importance as to affect the immediate interests of a large class of manufacturers, that methods are fallen upon, so far to prejudice the public mind, as to prevent any trial of consequence taking place during the currency of the patent, if such has been obtained; and the patentee, far from reaping any profit from his discovery, has only the mortification to see those very people, with many advantages on their side, strike into the path that he, alone, had chalked out.

Although nearly five years have elapsed since a patent was obtained by CATHCART DEMPSTER of St Andrews, for a most important improvement in the manufacture of Sail-canvas, yet has he hitherto been only able to *establish* its reputation on the East and West coasts of Scotland, and on board a few East India ships from the port of London. And even to do this required no small exertion. For he had not only to surmount the common obstacles opposed to every one in his situation, but to demonstrate, by actual proof, that an unfavourable report, which had been industriously circulated, had no foundation in fact. No one ventured to say that his canvas was made from coarse or ill prepared materials, or that it was liable to mildew. But another expedient was fallen upon. It was roundly asserted that it *would* stretch a great deal when put to use, from the peculiar circumstance of its being *entirely composed of twine*. This having some degree of plausibility, had the effect to deter many from making trial of it, as they were aware that such a fault would render some kind of sails perfectly useless. The Patentee now thinks himself fortunate, that this ideal fault having been strenuously urged, he has at length, on a fair trial being made, succeeded in convincing many of its futility; for he now has it in his power to state, that this, the only objection that was ever found against his invention, is more than obviated; as all who have had actual experience of the Patent canvas, *declare that it stretches* LESS than common sailcloth.

DEMPSTER'S PATENT CANVAS, *both in warp and weft*, is made from two-ply *twine of nearly the same grist*, properly prepared by boiling or bleaching before it is weaved. Its strength is so extraordinary, that No. 3. or 4. may be safely used in place of No. 1. of common sailcloth; and with this great advantage, that it is so pliable and easily handed, that those who heretofore went to sea in a vessel with *ten* seamen, now find *eight* perfectly sufficient; and, from the peculiar circumstance of this kind of cloth being weaved without the assistance of starch, or any other kind of dressing whatever, its great strength is never impaired by the unavoidable bane of ordinary canvas—rot and mildew. From the closeness of its texture, it holds a better wind than the other; and this superiority it continues to maintain in spite of the weather; for as it has no extraneous matter to lose, it is evident that the action of the weather will rather tend to thicken than to thin the fabric, as the twine will gradually plump out and fill up the interstices. Common canvas, as is well known, gets more and more porous every day, from the rain washing out part of the glutinous dressing unavoidably used in the process of its manufacture. Enough of this, however, remains, to be the efficient cause of mildew. But though it were possible to remove this leaven of putrefaction, yet, from the improper construction of the fabric, it *cannot* last any length of time; for, as the grist of the single yarns of which this canvas is made, is four or five times coarser in one direction of the fabric than in the other, the *fine* thread of the warp will be protruded from the general surface, (as it were on a ridge) by the *coarse* thread of the weft, and must be soon cut through by rubbing against every object with which it comes in contact;—of course, the cloth falls to pieces. The patent canvas, on the contrary, being altogether composed of twine of nearly the same size, has a more equal surface and bearing in both directions; and, therefore, is by no means so much exposed to injury from friction; of consequence, it must last a great deal longer than the other. This last consideration alone should entitle the Patent Canvas to a decided preference over the common sort. But when we take into the account how much *its superior strength tends to the preservation of* LIVES *and* PROPERTY, there surely can be no hesitation.

The small difference of price betwixt this and other sail-cloth, may, perhaps, act as a restraint on some people; but, to this, may be opposed the old saying, 'that those who buy dearest generally buy cheapest.' For if the patentee can believe the uniform testimony of every one who has made trial of his article for any length of time, it in the long run (independent of the security it affords) turns out fifty per cent. cheaper than any other canvas. In some measure to elucidate this, he begs leave only to state, that he now supplies a considerable part of the shipping of Dundee with his canvas; from which he will venture to draw the inference, that if this was not found to be a matter of considerable economy, no such preference would be given over their own sailcloth, which forms the chief staple manufacture of the place, and, it is believed, is there made in greater quantity than in any other part of the kingdom.

The present price of Patent Canvas is subjoined. If, however, the raw material continues to advance, it must be increased. But it may be observed, that the usual difference betwixt the Patent, and Common, Boiled or Bleached Canvas, is about fourpence a yard. There are two kinds of the Patent Canvas,—Bleached and Boiled. The Patentee would however recommend the latter, not only as it is cheaper, but, in his opinion, better than the former. The bleached kind is made merely in compliance with the taste of some of his customers; but he conceives the additional expense absolutely thrown away, as the boiled is fully stronger, and, from the nature of its preparation, in a short time becomes nearly as white. Nor has it in any instance, more than the other, been known to mildew.

Present Price of Dempster's Patent Canvas.

Bleached, 2s. 8d. } per yard, No. 1.
Boiled, - 2s. 5d. }

The lighter kinds fall a halfpenny per yard on every Number.

☞ Orders, addressed to the Patentee, will be attended to, in regular succession, according to their dates.

ST ANDREWS, Fifeshire,
7th January, 1809.

D. Willison, Printer, Edinburgh.

owing to the important discovery of the existence of heat in a state of composition with other matter. Heat thus combined loses its activity or becomes insensible, just in the same way as any other active substance loses its apparent qualities in composition. Acids, for example, when combined in a certain proportion with substances for which they have strong attraction, as alkalies or absorbent earths, lose all their obvious acid qualities, and the compound turns out mild, and totally conceals the acid which it contains. In a similar manner, heat, when combined in certain proportions with other matter, loses its sensible qualities, and the compound conceals the heat which it contains. Heat, in this combined state, was called by its ingenious discoverer, Dr Black, *latent heat*, and it was found to be very abundant in the atmosphere, which owes its existence as an elastic fluid to the quantity of latent heat that it contains. After this discovery was made, Dr Crawford, considering that air was absorbed by a burning body, concluded that the heat which appears in the combustion of a combustible body, is the heat that had before existed in the air which was consumed by the burning body. M. Lavoisier and others, prosecuting this inquiry, found that the combustible body, while it is burning, unites with the basis of the air, and that the heat which the air contained, and which was the cause of the air existing in the state of air, is expelled. This absorption of the basis of the air by the burning body, and the reduction of this basis to a solid form, accounts for the increase of weight which a body acquires by burning; or, in other words, gives a reason why the matter into which a combustible body is converted by combustion, is heavier than the body from which it was produced. The same absorption of air is observable, when a metal is converted into a calx, and the additional weight of the calx is found to be precisely equal to the weight of the air absorbed during the calcination. On these principles, therefore, we now explain the phenomena in a much more satisfactory manner than by the supposition of phlogiston, or a principle of inflammability. See Chemistry.

PHLOMIS, the Sage-tree, or *Jerusalem Sage*; a genus of plants belonging to the didynamia class. See Botany *Index*.

PHLOX, Lychnidea, or *Bastard Lychnis*; a genus of plants belonging to the pentandria class. See Botany *Index*.

PHLYCTENÆ, in *Medicine*, small eruptions on the skin.

PHOCA, a genus of quadrupeds of the order of feræ. See Mammalia *Index*.

PHOCÆA, the last town of Ionia, (Mela, Pliny); of Æolis, (Ptolemy), because situated on the right or north side of the river Hermus, which he makes the boundary of Æolis to the south. It stood far in the land, on a bay or arm of the sea; had two very safe harbours, the one called *Lampter*, the other *Naustathmos*, (Livy). It was a colony of Ionians, situated in the territory of Æolis, (Herodotus). Massilia in Gaul was again a colony from it. *Phocænses*, the people, (Livy); *Phocaicus*, the epithet, (Lucan); applied to *Marseilles*. It was one of the 12 cities which assembled in the panionium or general council of Ionia.

Ancient Univ. Hist. vol. vi. Some writers tell us, that while the foundations of this city were laying, there appeared near the shore a great shoal of sea-calves; whence it was called *Phocæa*, the word *phoca* signifying in Greek a *sea-calf*. Ptolemy, who makes the river Hermus the boundary between Æolia and Ionia, places Phocæa in Æolis; but all other geographers reckon it among the cities of Ionia. It stood on the sea-coast, between Cuma to the north, and Smyrna to the south, not far from the Hermus; and was, in former times, one of the most wealthy and powerful cities of all Asia; but is now a poor beggarly village, though the see of a bishop. The Phocæans were expert mariners, and the first among the Greeks that undertook long voyages; which they performed in galleys of fifty oars. As they applied themselves to trade and navigation, they became acquainted pretty early with the coasts and islands of Europe, where they are said to have founded several cities, namely, Velia in Italy; Alalia, or rather Aleria, in Corsica; and Marseilles in Gaul. Neither were they unacquainted with Spain; for Herodotus tells us, that in the time of Cyrus the Great, the Phocæans arriving at Sartessus, a city in the bay of Cadiz, were treated with extraordinary kindness by Arganthonius king of that country; who, hearing that they were under no small apprehension of the growing power of Cyrus, invited them to leave Ionia, and settle in what part of his kingdom they pleased. The Phocæans could not be prevailed upon to forsake their country; but accepted a large sum of money, which that prince generously presented them with, to defray the expence of building a strong wall round their city. The wall they built on their return; but it was unable to resist the mighty power of Cyrus, whose general Harpagus, investing the city with a numerous army, soon reduced it to the utmost extremities. The Phocæans, having no hopes of any succour, offered to capitulate; but the conditions offered by Harpagus seeming severe, they begged he would allow them three days to deliberate; and in the mean time, withdraw his forces. Harpagus, though not ignorant of their design, complied with their request. The Phocæans, taking advantage of this condescension, put their wives, children, and all their most valuable effects, on board several vessels which they had ready equipped, and conveyed them safe to the island of Chios, leaving the Persians in possession of empty houses. Their design was to purchase the Oenessian islands, which belonged to the Chians, and settle there. But the Chians not caring to have them so near, lest they should engross all the trade to themselves, as they were a seafaring people, they put to sea again; and, having taken Phocæa, their native country, by surprise, put all the Persians they found in it to the sword. They went to Corsica; great part of them however returned very soon, as did the rest also in a few years. They then lived in subjection either to the Persians, or tyrants of their own. Among the latter we find mention made of Laodamus, who attended Darius Hystaspis in his expedition against the Scythians; and of Dionysius, who, joining Aristagoras, tyrant of Miletus, and chief author of the Ionian rebellion, retired, after the defeat of his countrymen, to Phœnicia, where he made an immense booty, seizing on all the ships he met with trading to that country. From Phœnicia he sailed to Sicily, where he committed great depredations on the Carthaginians and Tuscans; but is said never to have molested the Greeks.

In the Roman times the city of Phocæa sided with Antiochus

Phocæa, Phocas.

Antiochus the Great; whereupon it was besieged, taken, and plundered, by the Roman general; but allowed to be governed by its own laws. In the war which Aristonicus brother to Attalus, king of Pergamus, raised against the Romans, they assisted the former to the utmost of their power; a circumstance which so displeased the senate, that they commanded the town to be demolished, and the whole race of the Phocæans to be utterly rooted out. This severe sentence would have been put in execution, had not the Massilienses, a Phocæan colony, interposed, and, with much difficulty, assuaged the anger of the senate. Pompey declared Phocæa a free city, and restored the inhabitants to all the privileges they had ever enjoyed; whence, under the first emperors, it was reckoned one of the most flourishing cities of all Asia Minor. This is all we have been able to collect from the ancients touching the particular history of Phocæa.

PHOCAS, a Roman centurion, was raised to the dignity of emperor by the army, and was crowned at Constantinople about the year 603. The emperor Mauritius, who was thus deserted both by the army and the people, fled to Chalcedon with his five children, whom Phocas caused to be inhumanly murdered before his eyes, and then he murdered Mauritius himself, his brother, and several other persons who were attached to that family.

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Phocas, thus proclaimed and acknowledged at Constantinople, sent, according to custom, his own image and that of his wife Leontia to Rome, where they were received with loud acclamations, the people there being incensed against Mauritius on account of the cruel exactions of the exarchs, and his other ministers in Italy. Gregory, surnamed the Great, then bishop of Rome, caused the images to be lodged in the oratory of the martyr Cæsarius, and wrote letters to the new emperor, congratulating him upon his advancement to the throne, which he said was effected by a particular providence, to deliver the people from the innumerable calamities and heavy oppressions under which they had long groaned. Had we no other character of Phocas and Leontia but that which has been conveyed to us in Gregory's letters, we should rank him amongst the best princes mentioned in history; but all other writers paint him in quite different colours; and his actions, transmitted to us by several historians, evidently speak him a most cruel and blood-thirsty tyrant. He was of middling stature, says Cedrenus, deformed, and of a terrible aspect: his hair was red, his eye-brows met, and one of his cheeks was marked with a scar, which, when he was in a passion, grew black and frightful: he was greatly addicted to wine and women, blood-thirsty, inexorable, bold in speech, a stranger to compassion, in his principles a heretic. He endeavoured, in the beginning of his reign, to gain the affections of the people by celebrating the Circensian games with extraordinary pomp, and distributing on that occasion large sums among the people; but finding that instead of applauding they reviled him as a drunkard, he ordered his guards to fall upon them. Some were killed, many wounded, and great numbers were dragged to prison: but the populace rising, set them at liberty, and thenceforth conceived an irreconcileable aversion to the tyrant.

As soon as the death of Mauritius was known, Narses, who then commanded the troops quartered on the frontiers of Persia, revolted. Phocas, however, managed matters so as to gain him over to his interest, and then treacherously and cruelly burnt him alive. He endeavoured to strengthen his cause by respectable alliances; but his cruelty was such as to render him generally hated, for he spared neither sex nor age, and amongst others he murdered Constantina the widow of Mauritius, and her daughters. These cruelties were at length the cause of his downfall. He became universally hateful; and persons in great authority near his person conspired against him. This conspiracy, however, was discovered, and the persons concerned in it were all put to death. The following year, however, 610, he was overtaken by the fate he had so long deserved.

Phocas || Phocion.

Heraclius, the son of the governor of Africa, who bore the same name, taking upon him the title of emperor, and being acknowledged as such by the people of Africa, sailed from thence with a formidable fleet, and a powerful army on board, for Constantinople, while Nicetas marched thither by way of Alexandria and the Pentapolis. Heraclius steered his course to Abydus, where he was received with great demonstrations of joy by several persons of rank, who had been banished by Phocas. From Abydus he sailed to Constantinople, where he engaged and utterly defeated the tyrant's fleet. Phocas took refuge in the palace; but one Photinus, whose wife he had formerly debauched, pursuing him with a party of soldiers, forced the gates, dragged the cowardly emperor from the throne, and having stripped him of the imperial robes, and clothed him with a black vest, carried him in chains to Heraclius, who commanded first his hands and feet, then his arms, and at last his head, to be cut off: the remaining part of his body was delivered up to the soldiers, who burnt it in the forum. We are told, that Heraclius having reproached him with his evil administration, he answered, with great calmness, "It is incumbent upon you to govern better." Such was the end of this cruel tyrant, after he had reigned seven years and some months.

PHOCILIDES, a Greek poet and philosopher of Miletus, flourished about 540 years before the Christian era. The poetical piece now extant, attributed to him, is not of his composition, but of another poet who lived in the reign of Adrian.

PHOCION was a distinguished Athenian general and orator in the time of Philip II. of Macedon. His character is thus described in the Ancient Universal History. "He was too modest to solicit command, nor did he promote wars that he might raise his authority by them; though, taken either as a soldier, orator, statesman, or general, he was by far the most eminent Athenian of his time. As he was a most disinterested patriot, he could entertain no great affection for Philip: but as he perfectly well knew the disposition of his countrymen, and how unlikely they were long to support such measures as were necessary to humble the Macedonian power, he did not express himself vehemently, but chose rather to cultivate the esteem which on all occasions Philip showed for the state of Athens, as a mean of preserving her, when she should be reduced to that situation which he conceived they wanted virtue to prevent. From this character the reader will easily discern that

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Demosthenes

Phocion.

Demosthenes and he could not well agree. The former was always warm, his language copious, and his designs extensive; and Phocion, on the other hand, was of a mild temper, delivered his opinion in very few words, and proposed schemes at once necessary and easy to be effected. Yet he seldom or never concurred with the people, but spoke as poignantly against their vices as Demosthenes himself; insomuch that this orator once told him, 'The Athenians, Phocion, in some of their mad fits, will murder thee.' 'The same (answered he) may fall to thee, Demosthenes, if ever they come to be sober."

He was afterwards appointed to command the army which was sent to assist the Byzantines against Philip, whom he obliged to return to his own dominions. This truly great man, whom (though extremely poor) no sum could bribe to betray his country, and who at every risk on all occasions gave them sound advice, was at length accused by his ungrateful countrymen. This event happened in the year before Christ 318. He was sent to Athens by Polyperchon head of a faction in Macedonia, together with his friends, chained in carts, with this message, "That though he was convinced they were traitors, yet he left them to be judged by the Athenians as a free people." Phocion demanded whether they intended to proceed against him by form of law; and some crying out that they would, Phocion demanded how that could be if they were not allowed a fair hearing: but perceiving, by the clamour of the people, that no such thing was to be expected, he exclaimed, "As for myself, I confess the crime objected to me, and submit to the judgement of the law; but consider, O ye Athenians, what have these poor innocent men done that they should be involved in the same calamity with me?" The people replied with great vociferation, "They are your accomplices, and that is enough." Then the decree was read, adjudging them all to death, viz. Phocion, Nicocles, Aheudippus, Agamon, and Pythocles; these were present: Demetrius, Phalereus, Callimedon, Charicles, and others, were condemned in their absence. Some moved that Phocion might be tortured before he was put to death; nay, they were for bringing the rack into the assembly, and torturing him there. The majority, however, thought it enough if he was put to death, for which the decree was carried unanimously; some putting on garlands of flowers when they gave their votes. As he was going to execution, a person who was his intimate friend asked him if he had any message for his son? "Yes," replied Phocion; "tell him it is my last command that he forget how ill the Athenians treated his father."

The spleen of his enemies was not extinguished with his life: they passed a decree whereby his corpse was banished the Athenian territories; they likewise forbade any Athenians to furnish fire for his funeral pile. One Conopian took up the corpse, and carried it beyond Eleusina, where he borrowed some fire of a Megarian woman and burned it. A Megarian matron, who attended with her maid, raised on the place an honorary monument; and having gathered up the bones, carried them home, and buried them under her own hearth; praying at the same time thus to the Penates: "To you, O ye gods, guardians of this place, I commit the precious remains of the most excellent Phocion. Protect them, I beseech you, from all insults; and deliver them one day to be reposited in the sepulchre of his ancestors, when the Athenians shall become wiser." It was not long before this opportunity occurred. When the Athenians began to cool a little, and remember the many services they had received from Phocion, they decreed him a statue of brass; ordered his bones to be brought back at the public expence; and decreed that his accusers should be put to death. Agnonides, who was principally concerned in that tragedy, suffered; but Epicurus and Demophilus, who were also accomplices in it, fled. However, Phocion's son met with them, and executed his revenge upon them; which was almost the only good action he ever performed, as he had a very small share of his father's abilities, and not any of his virtues. Such is the fickleness and such the injustice of popular governments; failings which, if we are to judge from universal experience, are absolutely inseparable from them.

Phocion, Phocis.

PHOCIS, (Demosthenes, Strabo, Pausanias); a country of Greece, contained between Bœotia to the east and Locris to the west, but extending formerly from the Sinus Corinthiacus on the south to the sea of Eubœa on the north, and, according to Dionysius, as far as Thermopylæ; but reduced afterwards to narrower bounds. *Phocenses*, the people; *Phocicus*, the epithet, (Justin); *Bellum Phocicum*, the sacred war which the Thebans and Philip of Macedon carried on against them for plundering the temple at Delphi; and by which Philip paved the way to the sovereignty of all Greece, (Justin.) Its greatest length was from north to south, that is, from 38° 45′ to 39° 20′, or about 35 miles; but very narrow from east to west, not extending to 30 miles, that is, from 23° 10′ to 23° 40′ at the widest, but about 23 miles towards the Corinthian bay, and much narrower still towards the north. This country is generally allowed to have taken its name from Phocus the son of Ornytion, a native of Corinth; but having been soon after invaded by the Eginetæ, under the conduct of another Phocus, who was the son of Eacus king of Enopia, the memory of the first insensibly gave way to that of the second.

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In Phocis there were many celebrated mountains, such as Cythæron, HELICON, and PARNASSUS. The last two we have already noticed in the order of the alphabet. Cythæron was consecrated to the muses as well as the other two, and was consequently much celebrated by the poets. Both it and Helicon contend with Mount Parnassus for height and magnitude. There were no remarkable rivers in Phocis except Cephisus, which runs from the foot of Parnassus northward, and empties itself in the Pindus, which was near the boundary of that kingdom. It had several very considerable cities; such as Cyrra, Crissa, and ANTECYRA, which, according to Ptolemy, were on the sea coasts; and Pythia, Delphi, Daulis, Elatia, Ergosthenia, and Baulia, which were inland towns. Elatia was the largest and richest after Delphi.

Deucalion was king of that part of Phocis which lies about Parnassus, at the time that Cecrops flourished in Attica; but the Phocians afterwards formed themselves into a commonwealth, to be governed by their general assemblies, the members of which were chosen from among themselves, and were changed as often as occasion required. Of the history of the Phocians but little is known till the time of the holy war, of which

 we

we have the following account in the Ancient Universal History.

"The Phocians having presumed to plough the territories of the city of Cyrra, consecrated to the Delphic god, were summoned by the other Grecian states before the court of the Amphictyons, where a considerable fine was imposed upon them for their sacrilege. They refused to pay it, on pretence that it was too large; and at the next assembly their dominions were adjudged confiscated to the use of the temple. This second sentence exasperated the Phocians still more; who, at the instigation of one Philomelus, or, as he is called by Plutarch, Philomedes, seized upon the temple, plundered it of its treasure, and held the sacred depositum for a considerable time. This second crime occasioned another assembly of the Amphictyons, the result of which was a formal declaration of war against the Phocians. The quarrel being become more general, the several states took part in it according to their inclinations or interest. Athens, Sparta, and some others of the Peloponnesians, declared for the Phocians; and the Thebans, Thessalians, Locrians, and other neighbouring states, against them. A war was commenced with great fury on both sides, and styled *the holy war*, which lasted ten years; during which the Phocians, having hired a number of foreign troops, made an obstinate defence, and would in all probability have held out much longer had not Philip of Macedon given the finishing stroke to their total defeat and punishment. The war being ended, the grand council assembled again, and imposed an annual fine of 60 talents upon the Phocians, to be paid to the temple, and continued till they had fully repaired the damage it had sustained from them; and, till this reparation should be made, they were excluded from dwelling in walled towns, and from having any vote in the grand assembly. They did not, however, continue long under this heavy sentence: their known bravery made their assistance so necessary to the rest, that they were glad to remit it; after which remission they continued to behave with their usual courage and resolution, and soon obliterated their former guilt."

We cannot finish this article without mentioning more particularly Daulis, rendered famous, not so much for its extent or richness, as for the stature and prowess of its inhabitants; but still more for the inhuman repast which was served up to Tereus king of Thrace by the women of this city, by whom he was soon after murdered for the double injury he had done to his sister-in-law Philomela, daughter of Pandion king of Athens. See PHILOMELA.

PHOEBUS, one of the names given by ancient mythologists to the Sun, Sol, or Apollo. See APOLLO.

PHOENICIA, or more properly PHOENICE, the ancient name of a country lying between the 34th and 36th degrees of north latitude; bounded by Syria on the north and east, by Judæa on the south, and by the Mediterranean on the west. Whence it borrowed its name is not absolutely certain. Some derive it from one Phœnix; others from the Greek word *phœnix*, signifying a *palm* or *date*, as that tree remarkably abounded in this country. Some again suppose that Phœnice is originally a translation of the Hebrew word *Edom*, from the Edomites who fled thither in the days of David. By the contraction of Canaan it was also called *Chna*, and anciently *Rhabbothin* and *Colpitis* (A). The Jews commonly named it *Canaan*; though some part of it, at least, they knew by the name of *Syrophœnice* (B). Bochart tells us that the most probable etymology is *Phene Anak*, i. e. "the descendants of Anak." Such were the names peculiar to this small country; though Phœnice was sometimes extended to all the maritime countries of Syria and Judea, and Canaan to the Philistines, and even to the Amalekites. On the contrary, these two names, and the rest, were most generally swallowed up by those of Palestine and Syria (C).

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There is some disagreement among authors with respect to the northern limits of this country. Ptolemy makes the river Eleutherus the boundary of Phœnice to the north; but Pliny, Mela, and Stephanus, place it in the island of Aradus, lying north of that river. Strabo observes, that some will have the river Eleutherus to be the boundary of Seleucis, on the side of Phœnice and Cœlesyria. On the coast of Phœnice, and south of the river Eleutherus, stood the following cities: SIMYRA, Orthosia, TRIPOLIS, Botrys, Byblus, Palæbyblus, Berytus, SIDON, SAREPTA, TYRUS, Palætyrus.

Phœnice extended, according to Ptolemy, even beyond Mount Carmel; for that geographer places in Phœnice not only Ecdippa and Ptolemais, but Sycaminum and Dæra, which stand south of that mountain. These, however, properly speaking, belonged to Palestine. We will not take upon us to mark out the bounds of the midland Phœnice. Ptolemy reckons in it the following towns; Arca, Palæbyblus (Old Byblus), Gabala, and Cæsaria Paniæ. This province was considerably extended in the times of Christianity; when, being considered as a province of Syria, it included not only Damascus but Palmyra also.

The soil of this country is good, and productive of many necessaries for food and clothing. The air is wholesome, and the climate agreeable. It is plentifully watered by small rivers; which, running down from Mount Libanus, sometimes swell to an immoderate degree, either increased by the melting of the snows on that mountain, or by heavy rains. Upon these occasions they overflow, to the great danger and hinderance of the traveller and damage of the country. Among these rivers is that of ADONIS.

It

(A) This last name is a translation of the first. *Rabhotsen* is in Hebrew a *great gulf* or *bay*. From *rabhotsen*, by changing the Hebrew *ts* into the Greek *t*, comes *rabboten*; and, with a little variation, *rhabbothin*. Κολπος, *colpos*, is Greek also for a *bay* or *gulf*; whence it appears that *colpitis* or *colpites* is a translation of *rabbothin*.

(B) Bochart supposes that the borderers, both upon the Phœnician and Syrian side, were called by the common name of Syrophœnicians, as partaking equally of both nations.

(C) Or rather Phœnice, Palestine, and Syria, were promiscuously used for each other, and particularly the two former. Phœnice and Palestine, says Stephanus Byzantinus, were the same. As for Syria, we have already observed, that in its largest extent it sometimes comprehended Phœnice and Cœlesyria. Herodotus plainly confounds these three names; we mean, uses one for the other indifferently.

Phoenicia.

It is univerſally allowed that the Phœnicians were Canaanites (D) by deſcent: nothing is plainer or leſs conteſted, and therefore it were time loſt to prove it. We ſhall only add, that their blood muſt have been mixed with that of foreigners in proceſs of time, as it happens in all trading places; and that many ſtrange families muſt have ſettled among them, who could conſequently lay no claim to this remote origin, how much ſoever they may have been called Phœnicians, and reckoned of the ſame deſcent with the ancient proprietors.

The Phœnicians were governed by kings; and their territory, as ſmall a ſlip as it was, included ſeveral kingdoms; namely, thoſe of Sidon, Tyre, Aradus, Berytus, and Byblus. In this particular they imitated and adhered to the primitive government of their forefathers; who, like the other Canaanites, were under many petty princes, to whom they allowed the ſovereign dignity, reſerving to themſelves the natural rights and liberties of mankind. Of their civil laws we have no particular ſyſtem.

With regard to religion, the Phœnicians were the moſt groſs and abominable idolaters. The Baal-berith, Baalzebub, Baalſamen, &c. mentioned in Scripture, were ſome of the Phœnician gods; as were alſo the Moloch, Aſhtaroth, and Thammuz, mentioned in the ſacred writings.—The word *Baal*, in itſelf an appellative, was no doubt applied to the true God, until he rejected it on account of its being ſo much profaned by the idolaters. The name was not appropriated to any particular deity among the idolatrous nations, but was common to many; however, it was generally imagined that one great God preſided over all the reſt. Among the Phœnicians this deity was named *Baal-ſamen;* whom the Hebrews would have called *Baal ſhemim*, or the God of heaven. In all probability this was alſo the principal Carthagiuian deity, though his Punic name is unknown. We have many religious rites of the Carthaginians handed down to us by the Greek and Roman writers; but they all beſtowed names of their own gods upon thoſe of the Carthaginians, which leads us to a knowledge of the correſpondence between the characters of the Phœnician and European deities. The principal deity of Carthage, according to Diodorus Siculus, was Chronus or Saturn. The ſacrifices offered up to him were children of the beſt families. Our author alſo tells us, that the Carthaginians had a brazen ſtatue or coloſſus of this god, the hands of which were extended in act to receive, and bent downwards in ſuch a manner, that the child laid thereon immediately fell down into a hollow where there was a fiery furnace. He adds alſo, that this inhuman practice ſeemed to confirm a tradition, handed down to the Greeks from very early antiquity, viz. that Saturn devoured his own children.

The goddeſs Cœleſtis, or Urania, was held in the higheſt veneration by the Carthaginians. She is thought to have been the ſame with the queen of heaven mentioned in Jeremiah, the Juno Olympia of the Greeks. According to Heſychius, the ſame word applied in the Punic language both to Juno and Venus: Nay, the ancient Greeks frequently confound Juno, Venus, and Diana or the moon, all together; which is to be attributed to the Egyptians and Phœnicians, from whom they received their ſyſtem of religion; who ſeem in the moſt ancient times to have had but one name for them all. Beſides theſe there were ſeveral other deities of later date, who were worſhipped among the Phœnicians, particularly thoſe of Tyre, and conſequently among the Carthaginians alſo. Theſe were Jupiter, Apollo, Mars, and Bacchus. Jupiter was worſhipped under the name of *Belus* or *Baal.* To him they addreſſed their oaths; and placed him for the moſt part, as there is reaſon to believe, at the head of their treaties. The ſame name was alſo given to the other two, whence they were frequently miſtaken for one another. Apollo or the ſun, went either by this name ſimply, or by others of which this made a part.

The Carthaginian ſuperſtition, however, was not confined to theſe deities alone. They worſhipped alſo the fire, air, and other elements; and had gods of rivers, meads, &c. Nay, they paid divine honours to the ſpirits of their heroes, and even to men and women themſelves while yet in life; and in this adoration Hannibal the Great had for ſome time a ſhare, notwithſtanding the infamous conduct of his countrymen towards him at laſt. In order to worſhip thoſe gods with more conveniency on all occaſions, the Carthaginians had a kind of portable temples. Theſe were only covered chariots, in which were ſome ſmall images repreſenting their favourite deities; and which were drawn by oxen. They were alſo a kind of oracle; and their reſponſes were underſtood by the motion impreſſed upon the vehicle. This was likewiſe an Egyptian or Libyan cuſtom; and Tacitus informs us that the ancient Germans had ſomething of the ſame kind. The tabernacle of Moloch is thought to have been a machine of this kind; and it is not improbable that the whole was derived from the tabernacle of the Jews in the wilderneſs.

Beſides all the deities above-mentioned, we ſtill find another, named the *Dæmon* or *Genius* of Carthage, mentioned in the treaty made by Philip of Macedon and Hannibal. What this deity might be, we know not; however, it may be obſerved, that the pagan world in general believed in the exiſtence of demons, or intelligences who had a kind of middle nature between gods and men, and to whom the adminiſtration of the world was in a great meaſure committed. Hence it is no wonder that they ſhould have received religious honours. For when once mankind were poſſeſſed with the opinion that they were the miniſters of the gods, and truſted with the diſpenſation of their favours, as well as the infliction

(D) Bochart inſinuates that the Canaanites were aſhamed of their name, on account of the curſe denounced on their progenitor, and terrified by the wars ſo vigorouſly and ſucceſsfully waged on them by the Iſraelites, purely becauſe they were Canaanites; and that therefore, to avoid the ignominy of the one and the danger of the other, they abjured their old name, and changed it for Phœnicians, Syrians, Syrophœnicians, and Aſſyrians. Heidegger conjectures alſo that they were aſhamed of their anceſtor Canaan.

Phoenicia.

fliction of their punishments, it is natural to suppose that they would be desirous of making their addresses to them. See ASTARTE and POLYTHEISM.

Herodotus supposes the Phœnicians to have been circumcised; but Josephus asserts, that none of the nations included under the vague name of Palestine and Syria used that rite, the Jews excepted; so that if the Phœnicians had anciently that custom, they came in time to neglect it, and at length wholly laid it aside. They abstained however from the flesh of swine.

Much is said of their arts, sciences, and manufactures; but as what we find concerning them is couched in general terms only, we cannot descant on particulars. The Sidonians, under which denomination we comprehend the Phœnicians in general, were of a most happy genius. They were from the beginning addicted to philosophical exercises of the mind; insomuch that a Sidonian, by name Moschus, taught the doctrine of atoms before the Trojan war: and Abomenus of Tyre puzzled Solomon by the subtilty of his questions. Phœnice continued to be one of the seats of learning, and both Tyre and Sidon produced their philosophers of later ages; namely, Boethus and Diodatus of Sidon, Antipater of Tyre, and Appollonius of the same place; who gave an account of the writings and disciples of Zeno. For their language, see PHILOLOGY, nº 61. As to their manufactures, the glass of Sidon, the purple of Tyre, and the exceeding fine linen they wove, were the product of their own country, and their own invention: and for their extraordinary skill in working metals, in hewing timber and stone; in a word, for their perfect knowledge of what was solid, great, and ornamental in architecture—we need only put the reader in mind of the large share they had in erecting and decorating the temple at Jerusalem under their king Hiram. Their fame for taste, design, and ingenious invention, was such, that whatever was elegant, great, or pleasing, whether in apparel, vessels, or toys, was distinguished by way of excellence with the epithet of Sidonian.

The Phœnicians were likewise celebrated merchants, navigators, and planters of colonies in foreign parts. As merchants, they may be said to have engrossed all the commerce of the western world: as navigators, they were the boldest, the most experienced, and greatest discoverers, of the ancient times: they had for many ages no rivals. In planting colonies they exerted themselves so much, that, considering their habitation was little more than the slip of ground between Mount Libanus and the sea, it is surprising how they could furnish such supplies of people, and not wholly depopulate their native country.

It is generally supposed that the Phœnicians were induced to deal in foreign commodities by their neighbourhood with the Syrians, who were perhaps the most ancient of those who carried on a considerable and regular trade with the more eastern regions: and this conjecture appears probable at least; for their own territory was but small, and little able to afford any considerable exports, if we except manufactures: but that their manufactures were anyways considerable till they began to turn all the channels of trade into their own country, it is hard to believe. In Syria, which was a large country, they found store of productions of the natural growth of that soil, and many choice and useful commodities brought from the east. Thus, having a safe coast, with convenient harbours, on one side, and excellent materials for ship-building on the other; perceiving how acceptable many commodities that Syria furnished would be in foreign parts, and being at the same time, perhaps, shown the way by the Syrians themselves, who may have navigated the Mediterranean—they turned all their thoughts to trade and navigation, and by an uncommon application soon eclipsed their masters in that art.

It were in vain to talk of the Edomites, who fled hither in David's time; or to inquire why Herodotus supposes the Phœnicians came from the Red sea: their origin we have already seen. That some of the Edomites fled into this country in the days of David, and that they were a trading people, is very evident: what improvements they brought with them into Phœnice, it is hard to say; and by the way, it is as difficult to ascertain their numbers. In all probability they brought with them a knowledge of the Red sea, and of the south parts of Arabia, Egypt, and Ethiopia; and by their information made the Phœnicians acquainted with those coasts; by which means they were enabled to undertake voyages to those parts, for Solomon, and Pharoah Necho, king of Egypt.

Their whole thoughts were employed on schemes to advance their commerce. They affected no empire but that of the sea; and seemed to aim at nothing but the peaceable enjoyment of their trade. This they extended to all the known parts they could reach; to the British isles, commonly understood by the Cassiterides; to Spain, and other places in the ocean, both within and without the straits of Gibraltar; and, in general, to all the ports of the Mediterranean, the Black sea, and the lake Mæotis. In all these parts they had settlements and correspondents, from which they drew what was useful to themselves, or might be so to others; and thus they exercised the three great branches of trade, as it is commonly divided into importation, exportation, and transportation, in full latitude. Such was their sea-trade; and for that which they carried on by land in Syria, Mesopotamia, Assyria, Babylonia, Persia, Arabia, and even in India, it was of no less extent, and may give us an idea of what this people once was, how rich and how deservedly their merchants are mentioned in Scripture as equal to princes. Their country was, at that time, the great warehouse, where every thing that might either administer to the necessities or luxury of mankind was to be found; which they distributed as they judged would be the best for their own interest. The purple of Tyre, the glass of Sidon, and the exceeding fine linen made in this country, together with other curious pieces of art in metals and wood, already mentioned, appear to have been the chief and almost only commodities of Phœnice itself. Indeed their territory was so small, that it is not to be imagined they could afford to export any of their own growth; it is more likely that they rather wanted than abounded with the fruits of the earth.

Having thus spoken in general terms of their trade, we shall now touch upon their shipping and some things remarkable in their navigation. Their larger embarkations were of two sorts; they divided them into round ships or gauli; and long ships, galleys, or triremes. When they drew up in line of battle, the gauli were disposed

posed at a small distance from each other in the wings, or in the van and the rear: their triremes were contracted together in the centre. If, at any time, they observed that a stranger kept them company in their voyage, or followed in their track, they were sure to get rid of him if they could, or deceive him if possible; in which policy they went so far, as to venture the loss of their ships, and even their lives; so jealous were they of foreigners, and so tenaciously bent on keeping the whole trade to themselves. In order to discourage other nations from engaging in commerce, they practised piracy, or pretended to be at war with such as they met when they thought themselves strongest. This was but a natural stroke of policy in people who grasped at the whole commerce of the then known world. We must not forget here the famous fishery of Tyre, which so remarkably enriched that city. See ASTRONOMY, n°. 7. OPHIR, and TYRE.

PHOENICOPTERUS, or FLAMINGO, a genus of birds belonging to the order of grallæ. See ORNITHOLOGY *Index*.

PHOENIX, in *Astronomy*. See ASTRONOMY *Index*.

PHOENIX, the *Great Palm*, or *Date tree*, a genus of plants belonging to the order of palmæ. See BOTANY *Index*. As the account of this valuable plant already given in its proper place, under BOTANY, is rather short to be satisfactory, we shall here enter a little more into the detail of its natural history. There is only one species, viz. the dactylifera, or common date-tree, a native of Africa and eastern countries, where it grows to 50, 60, and 100 feet high. The trunk is round, upright, and studded with protuberances, which are the vestiges of the decayed leaves. From the top issues forth a cluster of leaves or branches eight or nine feet long, extending all around like an umbrella, and bending a little towards the earth. The bottom part produces a number of stalks like those of the middle, but seldom shooting so high as four or five feet. These stalks, says Adanson, diffuse the tree very considerably; so that, wherever it naturally grows in forests, it is extremely difficult to open a passage through its prickly leaves. The date-tree was introduced into Jamaica soon after the conquest of the island by the Spaniards. There are however, but few of them in Jamaica at this time. The fruit is somewhat in the shape of an acorn. It is composed of a thin, light, and glossy membrane, somewhat pellucid and yellowish; which contains a fine, soft, and pulpy fruit, which is firm, sweet, and somewhat vinous to the taste, esculent, and wholesome; and within this is inclosed a solid, tough, and hard kernel, of a pale grey colour on the outside, and finely marbled within like the nutmeg. For medicinal use dates are to be chosen large, full, fresh, yellow on the surface, soft and tender, not too much wrinkled; such as have a vinous taste, and do not rattle when shaken. They are produced in many parts of Europe, but never ripen perfectly there. The best are brought from Tunis; they are also very fine and good in Egypt and in many parts of the east. Those of Spain and France look well; but are never perfectly ripe, and very subject to decay. They are preserved three different ways; some pressed and dry; others pressed more moderately, and again moistened with their own juice; and others not pressed at all, but moistened with the juice of other dates, as they are packed up, which is done in baskets or skins. Those preserved in this last way are much the best. Dates have always been esteemed moderately strengthening and astringent.

Though the date tree grows everywhere indiscriminately on the northern coasts of Africa, it is not cultivated with care, except beyond Mount Atlas; because the heat is not sufficiently powerful along the coasts to bring the fruits to proper maturity. We shall here extract some observations from Mr Des Fontaines respecting the manner of cultivating it in Barbary, and on the different uses to which it is applied. All that part of the Zaara which is near Mount Atlas, and the only part of this vast desert which is inhabited, produces very little corn; the soil being sandy, and burnt up by the sun, is almost entirely unfit for the cultivation of grain, its only productions of that kind being a little barley, maize, and sorgo. The date-tree, however, supplies the deficiency of corn to the inhabitants of these countries, and furnishes them with almost the whole of their subsistence. They have flocks of sheep; but as they are not numerous, they preserve them for the sake of their wool; besides, the flesh of these animals is very unwholesome food in countries that are excessively warm; and these people, though ignorant, have probably been enabled by experience to know that it was salutary for them to abstain from it. The date trees are planted without any order, at the distance of 12 feet one from the other, in the neighbourhood of rivulets and streams which issue from the sand. Forests of them may be seen here and there, some of which are several leagues in circumference. The extent of these plantations depends upon the quantity of water which can be procured to water them: for they require much moisture. All these forests are intermixed with orange, almond, and pomegranate trees, and with vines which twist round the trunks of the date trees; and the heat is strong enough to ripen the fruit, though they are never exposed to the sun.

Along the rivulets and streams, dykes are erected to stop the course of their waters, in order that they may be distributed amongst the date trees by means of small canals. The number of canals is fixed for each individual; and in several cantons, to have a right to them, the proprietors are obliged to pay an annual sum proportionable to the number and extent of their plantations. Care is taken to till the earth well, and to raise a circular border around the root of each tree, that the water may remain longer and in larger quantity. The date trees are watered in every season, but more particularly during the great heats of summer.

It is generally in winter that new plantations of this tree are formed. For this purpose those who cultivate them take shoots of those which produce the best dates, and plant them at a small distance one from the other. At the end of three or four years these shoots, if they have been properly taken care of, begin to bear fruit; but this fruit is as yet dry, without sweetness, and even without kernels; they never reach the highest degree of perfection of which they are susceptible till they are about 15 or 20 years old.

These plants are however produced from the seeds taken out of the fruit, provided they are fresh. They should be sown in pots filled with light rich earth, and plunged into a moderate hotbed of tanners bark, which should

Phoenix. should be kept in a moderate temperature of heat, and the earth frequently refreshed with water. When the plants are come up to a proper size, they should be each planted in a separate small pot, filled with the same light earth, and plunged into a hotbed again, observing to refresh them with water, as also to let them have air in proportion to the warmth of the season and the bed in which they are placed. During the summer time they should remain in the same hotbed; but in the beginning of August, they should have a great share of air to harden them against the approach of winter; for if they are too much forced, they will be so tender as not to be preserved through the winter without much difficulty, especially if you have not the conveniency of a bark stove to keep them in. The soil in which these plants should be placed, must be composed in the following manner, viz. half of light fresh earth taken from a pasture-ground, the other half sea sand and rotten dung or tanners bark in equal proportion; these should be carefully mixed, and laid in a heap three or four months at least before it is used, but should be often turned over to prevent the growth of weeds, and to sweeten the earth.

The trees, however, which spring from seed never produce so good dates as those that are raised from shoots; they being always poor and ill tasted. It is undoubtedly by force of cultivation, and after several generations, that they acquire a good quality.

The date trees which have been originally sown, grow rapidly, and we have been assured that they bear fruit in the fourth or fifth year. Care is taken to cut the inferior branches of the date tree in proportion as they rise; and a piece of the root is always left of some inches in length, which affords the easy means of climbing to the summit. These trees live a long time, according to the account of the Arabs; and in order to prove it, they say that when they have attained to their full growth, no change is observed in them for the space of three generations.

The number of females which are cultivated is much superior to that of the males, because they are much more profitable. The sexual organs of the date tree grow, as is well known, upon different stalks, and these trees flower in the months of April and May, at which time the Arabs cut the male branches to impregnate the female. For this purpose, they make an incision in the trunk of each branch which they wish to produce fruit, and place in it a stalk of male flowers; without this precaution the date tree would produce only abortive fruit (A). In some cantons the male branches are only shaken over the female. The practice of impregnating the date tree in this manner is very ancient. Pliny describes it very accurately in that part of his work where he treats of the palm tree. Phoenix.

There is scarcely any part of the date tree which is not useful. The wood, though of a spongy texture, lasts such a number of years, that the inhabitants of the country say it is incorruptible. They employ it for making beams and instruments of husbandry; it burns slowly, but the coals which result from its combustion are very strong, and produce a great heat.

The Arabs strip the bark and fibrous parts from the young date trees, and eat the substance which is in the centre; it is very nourishing, and has a sweet taste: it is known by the name of the marrow of the date tree. They eat also the leaves, when they are young and tender, with lemon juice; the old ones are laid out to dry, and are employed for making mats and other works of the same kind, which are much used, and with which they carry on a considerable trade in the interior parts of the country. From the sides of the stumps of the branches which have been left arise a great number of delicate filaments, of which they make ropes, and which might serve to fabricate cloth.

Of the fresh dates and sugar, says Hasselquist, the Egyptians make a conserve, which has a very pleasant taste. In Egypt they use the leaves as fly-flaps, for driving away the numerous insects which prove so troublesome in hot countries. The hard boughs are used for fences and other purposes of husbandry; the principal stem for building. The fruit, before it is ripe, is somewhat astringent; but when thoroughly mature, is of the nature of the fig. The Senegal dates are shorter than those of Egypt, but much thicker in the pulp, which is said to have a sugary agreeable taste, superior to that of the best dates of the Levant.

A white liquor, known by the name of *milk*, is drawn also from the date tree. To obtain it, all the branches are cut from the summit of one of these trees, and after several incisions have been made in it, they are covered with leaves, in order that the heat of the sun may not dry it.

The sap drops down into a vessel placed to receive it, at the bottom of a circular groove, made below the incisions. The milk of the date tree has a sweet and agreeable taste when it is new; it is very refreshing, and it is even given to sick people to drink, but it generally turns sour at the end of 24 hours. Old trees are chosen for this operation, because the cutting of the branches, and the large quantity of sap which flows from them, greatly exhaust them, and often cause them to decay.

The male flowers of the date tree are also useful. They

(A) The celebrated Linnæus, in his Dissertation on the Sexes of Plants, speaking of the date tree, says, "A female date-bearing palm flowered many years at Berlin without producing any seeds; but the Berlin people taking care to have some of the blossoms of the male tree, which was then flowering at Leipsic, sent to them by the post, they obtained fruit by these means; and some dates, the offspring of this impregnation, being planted in my garden, sprung up, and to this day continue to grow vigorously. Kœmpfer formerly told us, how necessary it was found by the oriental people, who live upon the produce of palm-trees, and are the true *Lotophagi*, to plant some male trees among the females, if they hoped for any fruit: hence it is the practice of those who make war in that part of the world to cut down all the male palms, that a famine may afflict their proprietors; sometimes even the inhabitants themselves destroy the male trees when they dread an invasion, that their enemies may find no sustenance in the country."

Phœnix.

They are eaten when ſtill tender, mixed up with a little lemon juice. They are reckoned to be very provocative: the odour which they exhale is probably the cauſe of this property being aſcribed to them.

Theſe date trees are very lucrative to the inhabitants of the deſert. Some of them produce 20 bunches of dates; but care is always taken to lop off a part of them, that thoſe which remain may become larger; 10 or 12 bunches only are left on the moſt vigorous trees.

It is reckoned that a good tree produces, one year with another, about the value of 10 or 12 ſhillings to the proprietor. A pretty conſiderable trade is carried on with dates in the interior part of the country, and large quantities of them are exported to France and Italy. The crop is gathered towards the end of November. When the bunches are taken from the tree, they are hung up in ſome very dry place where they may be ſheltered and ſecure from inſects.

Dates afford wholeſome nouriſhment, and have a very agreeable taſte when they are freſh. The Arabs eat them without ſeaſoning. They dry and harden them in the ſun, to reduce them to a kind of meal, which they lay up in ſtore to ſupply themſelves with food during the long journeys which they often undertake acroſs their deſerts. This ſimple food is ſufficient to nouriſh them for a long time.—The inhabitants of the Zaara procure alſo from their dates a kind of honey which is exceedingly ſweet. For this purpoſe they chooſe thoſe which have the ſofteſt pulp; and having put them into a large jar with a hole in the bottom, they ſqueeze them by placing over them a weight of eight or ten pounds.—The moſt fluid part of the ſubſtance, which drops through the hole, is what they call the *honey* of the date.

Even the ſtones, though very hard, are not thrown away. They give them to their camels and ſheep as food, after they have bruiſed them or laid them to ſoften in water.

The date, as well as other trees which are cultivated, exhibits great variety in its fruit, with reſpect to ſhape, ſize, quality, and even colour. There are reckoned to be at leaſt twenty different kinds. Dates are very liable to be pierced by worms, and they ſoon corrupt in moiſt or rainy weather.

From what has been ſaid, it may eaſily be perceived, that there is, perhaps, no tree whatever uſed for ſo many and ſo valuable purpoſes as the date tree.

Phoenix, in antiquity, a famous bird, which is generally looked upon by the moderns as fabulous. The ancients ſpeak of this bird as ſingle, or the only one of its kind; they deſcribe it as of the ſize of an eagle; its head finely creſted with a beautiful plumage, its neck covered with feathers of a gold colour, and the reſt of its body purple, only the tail white, and the eyes ſparkling like ſtars: they hold, that it lives 500 or 600 years in the wilderneſs; that when thus advanced in age, it builds itſelf a pile of ſweet wood and aromatic gums, and fires it with the wafting of its wings, and thus burns itſelf; and that from its aſhes ariſes a worm, which in time grows up to be a phœnix. Hence the Phœnicians gave the name of *phœnix* to the palm-tree; becauſe when burnt down to the root it riſes again fairer than ever.

In the ſixth book of the Annals of Tacitus, ſect. 28, it is obſerved that, in the year of Rome 787, the phœnix reviſited Egypt; which occaſioned among the learned much ſpeculation. This being is ſacred to the ſun. Of its longevity the accounts are various. The common perſuaſion is, as we have mentioned above, that it lives 500 years; though by ſome the date is extended to 1461. The ſeveral eras when the phœnix has been ſeen are fixed by tradition. The firſt, we are told, was in the reign of Seſoſtris; the ſecond in that of Amaſis; and, in the period when Ptolemy the third of the Macedonian race was ſeated on the throne of Egypt, another phœnix directed its flight towards Heliopolis. When to theſe circumſtances are added the brilliant appearance of the phœnix, and the tale that it makes frequent excurſions with a load on its back, and that when, by having made the experiment through a long tract of air, it gains ſufficient confidence in its own vigour, it takes up the body of its father and flies with it to the altar of the ſun to be there conſumed; it cannot but appear probable, that the learned of Egypt had enveloped under this allegory the philoſophy of comets.

Phœnix, Pholas.

Phoenix, ſon of Amyntor king of Argos by Cleobule or Hippodamia, was preceptor to young Achilles. His father having proved faithleſs to his wife, through fondneſs for a concubine called *Clytia*, Cleobule, who was jealous of him, perſuaded her ſon Phœnix to ingratiate himſelf with his father's miſtreſs. Phœnix eaſily ſucceeded; but Amyntor diſcovering his intrigues, he drew a curſe upon him, and the ſon was ſoon after deprived of his ſight by divine vengeance. Some ſay that Amyntor himſelf put out his ſon's eyes, which ſo cruelly provoked him that he meditated the death of his father. Reaſon and piety, however, prevailed over paſſion; and that he might not become a parricide, Phœnix fled from Argos to the court of Peleus king of Phthia. Here he was treated with tenderneſs; Peleus carried him to Chiron, who reſtored his eyeſight; ſoon after which he was made preceptor to Achilles, his benefactor's ſon. He was alſo preſented with the government of many cities, and made king of the Dolopes. He went with his pupil to the Trojan war; and Achilles was ever grateful for the inſtructions and precepts which he had received from him. After the death of Achilles, Phœnix, with others, was commiſſioned by the Greeks to return into Greece, to bring to the war young Pyrrhus. This commiſſion he ſucceſsfully performed; and after the fall of Troy, he returned with Pyrrhus, and died in Thrace. He was buried, according to Strabo, near Trachinia, where a ſmall river in the neighbourhood received the name of *Phœnix*. There was another Phœnix, ſon of Agenor, by a nymph who was called *Telephaſſa*, according to Apollodorus and Moſchus, or, according to others, *Epimeduſa*, *Perimeda*, or *Agriope*. He was, like his brother Cadmus, and Cilix, ſent by his father in purſuit of his ſiſter Europa, whom Jupiter had carried away under the form of a bull; and when his inquiries proved unſucceſsful, he ſettled in a country, which, according to ſome, was from him called *Phœnicia*. From him, as ſome ſuppoſe, the Carthaginians were called *Pœni*.

PHOLAS, a genus of ſhell-fiſh belonging to the order of vermes teſtacea. See Conchology *Index*.

The word *pholas* is derived from the Greek, and ſignifies ſomething which lies hid. This name they derive from

Pholas.

from their property of making themselves holes in the earth, sand, wood, or stone, and living in them. The means of their getting there, however, are as yet entirely unknown. All that we can know with certainty is, that they must have penetrated these substances when very small; because the entrance of the hole in which the pholas lodges is always much less than the inner part of it, and indeed than the shell of the pholas itself. Hence some have supposed that they were hatched in holes accidentally formed in stones, and that they naturally grew of such a shape as was necessary to fill the cavity.

The holes in which the pholades lodge are usually twice as deep, at least, as the shells themselves are long; the figure of the holes is that of a truncated cone, excepting that they are terminated at the bottom by a rounded cavity, and their position is usually somewhat oblique to the horizon. The openings of these holes are what betray the pholas being in the stone; but they are always very small in proportion to the size of the fish. There seems to be no progressive motion of any animal in nature so slow as that of the pholas; it is immersed in the hole, and has no movement except a small one towards the centre of the earth; and this is only proportioned to the growth of the animal. Its work is very difficult in its motion; but it has great time to perform it in, as it only moves downward, sinking itself deeper in the stone as it increases itself in bulk. That part by means of which it performs this, is a fleshy substance placed near the lower extremity of the shell; it is of the shape of a lozenge, and is considerably large in proportion to the size of the animal; and though it be of a soft substance, it is not to be wondered at that in so long a time it is able, by constant work, to burrow into a hard stone. The manner of their performing this may be seen by taking one of them out of the stone, and placing it upon some soft clay; for they will immediately get to work in bending and extending that part allotted to dig for them, and in a few hours they will bury themselves in the mud in as large a hole as they had taken many years to make in the stone. They find little resistance in so soft a substance; and the necessity of their hiding themselves evidently makes them hasten their work. The animal is lodged in the lower half of the hole in the stone, and the upper half is filled up by a pipe of a fleshy substance and conic figure, truncated at the end: this they usually extend to the orifice of the hole, and place on a level with the surface of the stone; but they seldom extend it any farther than this. The pipe, though it appears single, is in reality composed of two pipes, or at least it is composed of two parts separated by a membrane. The use of this pipe or proboscis is the same with that of the proboscis of other shell-fish, to take in sea-water into their bodies, and afterwards to throw it out again. In the middle of their bodies they have a small green vessel, the use of which has not yet been discovered. This, when plunged in spirit-of-wine, becomes of a purple colour: but its colour on linen does not become purple in the sun like that of the murex.

The pholas is remarkable for its luminous quality, which was noticed by Pliny, who observes that it shines in the mouth of the person who eats it; and if it touch his hands or clothes, it makes them luminous. He also says that the light depends upon its moisture. The light of this fish has furnished matter for various observations and experiments to M. Reaumur and the Bolognian academicians, especially Beccarius, who took so much pains with the subject of phosphoreal light.

Pholas.

M. Reaumur observes, that whereas other fishes give light when they tend to putrescence, this is more luminous in proportion to its being fresh; that when they are dried, their light will revive if they be moistened either with fresh or salt water, but that brandy immediately extinguishes it. He endeavoured to make this light permanent, but none of his schemes succeeded.

The attention of the Bolognian academicians was engaged to this subject by M. F. Marsilius in 1724, who brought a number of these fishes, and the stones in which they were inclosed, to Bologna, on purpose for their examination.

Beccarius observed, that though this fish ceased to shine when it became putrid, yet that in its most putrid state it would shine, and make the water in which it was immersed luminous when it was agitated. Galeatius and Montius found that wine or vinegar extinguished this light; that in common oil it continued some days, but in rectified spirit of wine or urine hardly a minute.

In order to observe in what manner this light was affected by different degrees of heat, they made use of a Reaumur's thermometer, and found that water rendered luminous by these fishes increased in light till the heat arrived to 45°, but that it then became suddenly extinct, and could not be revived again.

In the experiments of Beccarius, a solution of sea-salt increased the light of the luminous water; a solution of nitre did not increase it quite so much. Sal ammoniac diminished it a little, oil of tartar *per deliquium* nearly extinguished it, and the acids entirely. This water, poured upon fresh calcined gypsum, rock-crystal, ceruse, or sugar, became more luminous. He also tried the effects of it when poured upon various other substances, but there was nothing very remarkable in them. Afterwards, using luminous milk, he found that oil of vitriol extinguished the light, but that of tartar increased it.

This gentleman had the curiosity to try how differently coloured substances were affected by this kind of light; and having, for this purpose, dipped several ribbons in it, the white came out the brightest, next to this was the yellow, and then the green; the other colours could hardly be perceived. It was not, however, any particular colour, but only light, that was perceived in this case. He then dipped boards painted with the different colours, and also glass tubes filled with substances of different colours, in water rendered luminous by the fishes. In both these cases, the red was hardly visible, the yellow was the brightest, and the violet the dullest. But on the boards, the blue was nearly equal to the yellow, and the green more languid; whereas in the glasses, the blue was inferior to the green.

Of all the liquors to which he put the pholades, milk was rendered the most luminous. A single pholas made seven ounces of milk so luminous, that the faces of persons might be distinguished by it, and it looked as if it were transparent.

Air appeared to be necessary to this light: for when Beccarius put the luminous milk into glass tubes, no agitation would make it shine unless bubbles of air were mixed

Pholeys.

ed with it. Alſo Montius and Galeatius found, that, in an exhauſted receiver, the pholas loſt its light, but the water was ſometimes made more luminous: which they aſcribed to the riſing of bubbles of air through it.

Beccarius, as well as Reaumur, had many ſchemes to render the light of theſe pholades permanent. For this purpoſe he kneaded the juice into a kind of paſte with flour, and found that it would give light when it was immerſed in warm water; but it anſwered beſt to preſerve the fiſh in honey. In any other method of preſervation, the property of becoming luminous would not continue longer than ſix months, but in honey it had laſted above a year; and then it would, when plunged in warm water, give as much light as ever it had done. See Barbut's *Genera Vermium*, p. 14. &c.

PHOLEYS, or Foulies, are a people of Africa, of very peculiar manners. Some authors tell us, that the kingdom of Pholey, from whence they derive their name, is divided from that of Jaloff by a lake called in the language of the Mundingoes *Cayor;* and that it ſtretches from eaſt to weſt about 180 miles; but that, though it extends a great way ſouth, its limits in that direction are not exactly aſcertained.

Mr Moore, however, gives a very different account, and ſays, that the Pholeys live in clans, build towns, and are in very kingdom and country on each ſide of the river; yet are not ſubject to any of the kings of the country, though they live in their territories; for if they are uſed ill in one nation, they break up their towns, and remove to another. They have chiefs of their own, who rule with ſuch moderation, that every act of government ſeems rather an act of the people than of one man. This form of government is eaſily adminiſtered, becauſe the people are of a good and quiet diſpoſition, and ſo well inſtructed in what is juſt and right, that a man who does ill expoſes himſelf to univerſal contempt.

The natives of all theſe countries, not being avaricious of land, deſire no more than they can uſe; and as they do not plough with horſes or other cattle, they can uſe but very little; and hence the kings willingly allow the Pholeys to live in their dominions, and cultivate the earth.

The Pholeys have in general a tawney complexion, though many of them are of as deep a black as the Mundingoes; and it is ſuppoſed that their alliances with the Moors have given them the mixed colour between the true olive and the black. They are rather of a low ſtature, but have a genteel and eaſy ſhape, with an air peculiarly delicate and agreeable.

Though they are ſtrangers in the country, they are the greateſt planters in it. They are extremely induſtrious and frugal, and raiſe much more corn and cotton than they conſume, which they ſell at reaſonable rates; and are ſo remarkable for their hoſpitality, that the natives eſteem it a bleſſing to have a Pholey town in their neighbourhood; and their behaviour has gained them ſuch reputation, that it is eſteemed infamous for any one to treat them in an unhoſpitable manner. Their humanity extends to all, but they are doubly kind to people of their race; and if they know of any one of their body being made a ſlave, they will readily redeem him. As they have plenty of food, they never ſuffer any of their own people to want; but ſupport the old, the blind, and the lame, equally with the others.

Pholeys, Pholis.

Theſe people are ſeldom angry; and Mr Moore obſerves that he never heard them abuſe each other; yet this mildneſs is far from proceeding from want of courage, they being as brave as any people of Africa, and very expert in the uſe of their arms, which are javelins, cutlaſſes, bows and arrows, and upon occaſion guns. They uſually ſettle near ſome Mundingo town, there being ſcarce any of note up the river that has not a Pholey town near it. Moſt of them ſpeak Arabic, which is taught in their ſchools; and they are able to read the Koran in that language, though they have a vulgar tongue called *Pholey*. They are ſtrict Mahometans, and ſcarce any of them will drink brandy, or any thing ſtronger than ſugar and water.

They are ſo ſkilful in the management of cattle, that the Mundingoes leave theirs to their care. The whole herd belonging to a town feed all day in the ſavannahs, and after the crop is off, in the rice-grounds. They have a place without each town for their cattle, ſurrounded by a circular hedge, and within this encloſure they raiſe a ſtage about eight feet high, and eight or ten feet wide, covered with a thatched roof; all the ſides are open, and they aſcend to it by a ladder. Round this ſtage they fix a number of ſtakes, and when the cattle are brought up at night, each beaſt is tied to a ſeparate ſtake with a ſtrong rope made of the bark of trees. The cows are then milked, and four or five men ſtay upon the ſtage all night with their arms to guard them from the lions, tygers, and other wild beaſts. Their houſes are built in a very regular manner, they being round ſtructures, placed in rows at a diſtance from each other to avoid fire, and each of them has a thatched roof ſomewhat reſembling a high-crowned hat.

They are alſo great huntſmen, and not only kill lions, tygers, and other wild beaſts, but frequently go 20 or 30 in a company to hunt elephants; whoſe teeth they ſell, and whoſe fleſh they ſmoke-dry and eat, keeping it for ſeveral months together. As the elephants here generally go in droves of 100 or 200, they do great miſchief by pulling up the trees by the roots, and trampling down the corn; to prevent which, when the natives have any ſuſpicion of their coming, they make fires round their corn to keep them out.

They are almoſt the only people who make butter, and ſell cattle at ſome diſtance up the river. They are very particular in their dreſs, and never wear any other clothes but long robes of white cotton, which they make themſelves. They are always very clean, eſpecially the women, who keep their houſes exceedingly neat. They are, however, in ſome particulars very ſuperſtitious: for if they chance to know that any perſon who buys milk of them boils it, they will from thenceforth on no conſideration ſell that perſon any more, from their imagining that boiling the milk makes the cows dry.

PHOLIS, in *Natural Hiſtory*, is an old name for gypſums or plaſter-ſtones. The name is derived from φολις, a *ſcale* or *ſmall flake*, becauſe they are compoſed of particles of that form.

Pholis, in *Ichthyology*, is the name of a ſmall anguilliform fiſh. The back is brown, the belly is white, the whole back and ſides are ſpotted, and the ſkin is ſoft, free of ſcales, but with a tough mucilaginous matter

ter like the eel. This species most of all approaches to the *alauda*; and though usually larger, yet Mr Ray doubts whether it really differs from it in any thing essential; the distinction is its colour, which though a very obvious is certainly a very precarious one.

PHONICS, the doctrine or science of sound, otherwise called ACOUSTICS, which see.

PHORMIUM, FLAX-PLANT, (*Phormium tenax*, Forst.) is a name which we may give to a plant that serves the inhabitants of New Zealand instead of hemp and flax. Of this plant there are two sorts; the leaves of both resemble those of flags, but the flowers are smaller, and their clusters more numerous; in one kind they are yellow, and in the other a deep red. Of the leaves of these plants, with very little preparation, they make all their common apparel, and also their strings, lines, and cordage, for every purpose; which are so much stronger than any thing we can make with hemp, that they will not bear a comparison.—From the same plant, by another preparation, they draw long slender fibres, which shine like silk, and are as white as snow: of these, which are very strong, they make their finest cloths; and of the leaves, without any other preparation than splitting them into proper breadths, and tying the strips together, they make their fishing-nets, some of which are of an enormous size.

The seeds of this valuable plant were brought over into England; but, upon the first trial, appeared to have lost their vegetating power. We understand however that it has since succeeded with the aid of artificial heat.

The filamentous parts of different vegetables have been employed in different countries for the same mechanic uses as hemp and flax among us. Putrefaction, and in some degree alkaline lixivia, destroy the pulpy or fleshy matter, and leave the tough filaments entire. By curiously putrefying the leaf of a plant in water, we obtain the fine flexible fibres which constituted the basis of the ribs and minute veins, and which form as it were a skeleton of the leaf. In Madagascar, different kinds of cloth are prepared from the filaments of the bark of certain trees boiled in strong ley; and some of these cloths are very fine, and approach to the softness of silk, but in durability come short of cotton: others are coarser and stronger, and last thrice as long as cotton; and of these filaments they make sails and cordage to their vessels. The stalks of nettles are sometimes used for like purposes, even in France; and Sir Hans Sloane relates, in one of his letters to Mr Ray, that he has been informed by several, that muslin and callico, and most of the Indian linens, are made of nettles. A strong kind of cloth is said to be prepared in some of the provinces of Sweden of hop-stalks; and in the Transactions of the Swedish Academy for 1750, we have an account of an experiment relating to this subject: A quantity of stalks was gathered in autumn, which was equal in bulk to a quantity of flax sufficient to yield a pound after preparation. The stalks were put into water, and kept covered with it during the winter. In March, they were taken out, dried in a stove, and dressed as flax. The prepared filaments weighed nearly a pound, and proved fine, soft, and white; they were spun and wove into six ells of fine strong cloth. Unless the stalks are fully rotted, which will take much longer time than flax, the woody part will not separate, and the cloth will prove neither white nor fine.

PHOSPHATE is a saline body composed of phosphoric acid united to some base, as for instance, lime, which is called phosphate of lime. For an account of the different phosphates, see CHEMISTRY and MINERALOGY *Index*.

PHOSPHORUS, a name given to certain substances which shine in the dark without emitting heat. By this circumstance they are distinguished from the *pyrophori*, which though they take fire on being exposed to the air, are yet entirely destitute of light before this exposure.

Phosphori are divided into several kinds, known by the names of *Bolognian phosphorus*, *Mr Canton's phosphorus*, *Baldwin's phosphorus*, *phosphorus of urine*, &c. of which the last is by far the most remarkable both with respect to the quantity of light which it emits, and its property of taking fire and burning very fiercely upon being slightly heated or rubbed. For the method of preparing these, and for an account of their properties and combinations, see CHEMISTRY *Index*.

PHOTINIANS, in ecclesiastical history, were a sect of heretics in the fourth century who denied the divinity of our Lord. They derive their name from *Photinus* their founder, who was bishop of Sirmium, and a disciple of Marcellus. Photinus published in the year 343 his notions respecting the Deity, which were repugnant both to the orthodox and Arian systems. He asserted, that Jesus Christ was born of the Holy Ghost and the Virgin Mary; that a certain divine emanation, which he called the *Word*, descended upon Him; and that because of the union of the divine word with his human nature, He was called the son of God and even God himself; and that the Holy Ghost was not a person, but merely a celestial virtue proceeding from the Deity. Both parties condemned the bishop in the councils of Antioch and Milan, held in the years 345 and 347. He was condemned also by the council at Sirmium in 351, and was afterwards degraded from the episcopal dignity, and at last died in exile in the year 372 or 375. His opinions were afterwards revived by Socinus.

PHOTIUS, patriarch of Constantinople, was one of the finest geniuses of his time, and his merit raised him to the patriarchate; for Bardas having driven Ignatius from the see, Photius was consecrated by Asbestus in 859. He condemned Ignatius in a synod, whereupon the pope excommunicated him, and he, to balance the account, anathematized the pope. Basilius of Macedon, the emperor whom Photius had reproved for the murder of Michael the late emperor, expelled him, and restored Ignatius; but afterwards re-established Photius, upon Ignatius's death, in 878. At last, being wrongfully accused of a conspiracy against the person of Leo the philosopher, son and successor to Basilius, he was expelled by him in 886, and is supposed to have died soon after. He wrote a *Bibliotheca*, which contains an examen of 280 authors: we have also 253 epistles of his; the *Nomacanon* under 14 titles; an abridgement of the acts of several councils, &c. This great man was born in Constantinople, and was descended from a very illustrious and noble family. His natural abilities were very great, and he cultivated them with the greatest assiduity.

fiduity. There was no branch of literature, whether facred and profane, and fcarcely any art or fcience, in which he was not deeply verfed. Indeed he appears to have been by far the greateft man of the age in which he lived: and was fo intimately concerned in the chief tranfactions of it, that ecclefiaftical writers have on that account called it *Seculum Photianum*. He was firft raifed to the chief dignities of the empire, being made principal fecretary of ftate, captain of the guards, and a fenator. In all thefe ftations he acquitted himfelf with a diftinction fuitable to his great abilities; for he was a refined ftatefman, as well as a profound fcholar. His rife to the patriarchate was very quick; for when he was chofen to that office he was only a layman: but that he might be as it were gradually raifed to that dignity, he was made monk the firft day, reader the next, and the following days fub-deacon, deacon, and prieft. So that in the fpace of fix days he attained to the higheft office in the church. On the whole, however, his ardent love of glory and unbounded ambition made him commit exceffes which rendered him a fcourge to thofe about him.

Fabricius calls his *Bibliotheca* or library, *non liber, fed infignis thefaurus*, "not a book, but an illuftrious treafure," in which are contained many curious things, relating to authors, and many fragments of works which are no where elfe to be found. It was brought to light by Andreas Schottus, and communicated by him to David Hoefchelius, who caufed it to be printed in 1601. Schottus, confidering the great utility of this work, tranflated it into Latin, and printed his tranflation alone in 1606. The Greek text, together with the tranflation, was afterwards printed at Geneva in 1611.

PHOTOMER, an inftrument for afcertaining the intenfity of light. See Optics *Index*.

PHRAATES, or Phrahates. There were four kings of this name in Parthia. See Parthia.

PHRASE, in *Grammar*, an elegant turn or manner of fpeech, peculiarly belonging to this or that occafion, this or that art, or this or that language. Thus we fay, an Italian *phrafe*, an eaftern *phrafe*, a poetical *phrafe*, a rhetorical *phrafe*.

Phrase is fometimes alfo ufed for a fhort fentence or fmall fet or circuit of words conftructed together. In this fenfe, Father Buffier divides phrafes into complete and incomplete.

Phrafes are *complete* where there is a noun and a verb, each in its proper function; *i. e.* where the noun expreffes a fubject, and the verb the thing affirmed of it.

Incomplete phrafes are thofe where the noun and the verb together only do the office of a noun; confifting of feveral words without affirming any thing, and which might be expreffed in a fingle word. Thus, *that which is true*, is an incomplete phrafe, which might be expreffed in one word, *truth*; as, *that which is true fatisfies the mind*, i. e. *truth fatisfies the mind*.

PHRASEOLOGY, a collection of the phrafes or elegant expreffions in any language. See Phrase.

PHREATIS, or Phreattium, in Grecian antiquity, was a court belonging to the civil government of Athens, fituated upon the fea-fhore, in the Piræus. The name is derived from ἀπο τῦ φρεάτος, becaufe it ftood in a *pit*; or, as others fuppofe, from the hero *Phreatus*. This court heard fuch caufes as concerned perfons who had fled out of their own country for murder, or thofe that fled for involuntary murder, and who had afterwards committed a deliberate and wilful murder. The firft who was tried in this place was Teucer, on a groundlefs fufpicion that he had been acceffory to the death of Ajax. The accufed was not allowed to come to land, or fo much as to caft anchor, but pleaded his caufe in his bark; and if found guilty, was committed to the mercy of the winds and waves, or, as fome fay, fuffered there condign punifhment; if innocent, he was only cleared of the fecond fact, and, according to cuftom, underwent a twelvemonth's banifhment for the former. See Potter's *Gr. Antiq.* vol. i. p. 111.

PHRENETIC, a term ufed to denote thofe who, without being abfolutely mad, are fubject to fuch ftrong fallies of imagination as in fome meafure pervert their judgement, and caufe them to act in a way different from the more rational part of mankind.

PHRENITIS, the fame with Phrensy; an inflammation of the meninges of the brain, attended with an acute fever and delirium. See Medicine, N° 176; alfo an account of a ftrange degree of phrenzy which attacked Charles VI. of France, in the article France, N° 88, 90.

PHRYGANEA, a genus of infects, belonging to the order neuroptera. See Entomology *Index*.

PHRYGIA, a country in Afia. From whence it derived its name is not certain: fome fay it was from the river Phryx (now Sarabat), which divides Phrygia from Caria, and empties itfelf into the Hermus; others from Phrygia, the daughter of Afopus and Europa. The Greek writers tell us, that the country took its name from the inhabitants, and thefe from the town of Brygium in Macedonia, from whence they firft paffed into Afia, and gave the name of *Phrygia* or *Brygia* to the country where they fettled. Bochart is of opinion that this tract was called Phrygia from the Greek verb φρυγειν "to burn or parch;" which, according to him, is a tranflation of its Hebrew name, derived from a verb of the fame fignification.

Ancient Univerfal Hiftory, vol. iii. p. 441, &c.

No lefs various are the opinions of authors as to the exact boundaries of this country; an uncertainty which gave rife to an obfervation made by Strabo, viz. that the Phrygians and Myfians had diftinct boundaries; but that it was fcarce poffible to afcertain them. The fame writer adds, that the Trojans, Myfians, and Lydians, are, by the poets, all blended under the common name of Phrygians, which Claudian extends to the Pifidians, Bithynians, and Ionians. Phrygia Proper, according to Ptolemy, whom we choofe to follow, was bounded on the north by Pontus and Bithynia; on the weft by Myfia, Troas, the Ægean fea, Lydia, Mæonia, and Caria; on the fouth by Lycia; on the eaft by Pamphylia and Galatia. It lies between the 37th and 41ft degrees of north latitude, extending in longitude from 56 to 62 degrees. The inhabitants of this country, mentioned by Ptolemy, are the Lycaones and Anthemifenii, towards Lycia; and Moccadelis or Moccadine, the Cyddefes or Cydiffes towards Bithynia; and between thefe the Peitini or Speltini, the Moxiani, Phylacenfes, and Hierapolitæ. To thefe we may add the Berecyntes mentioned by Strabo.

Phrygia is commonly divided into the Greater and Leffer Phrygia, called alfo Troas. But this divifion did not take place till Troas was fubdued by the Phrygians; and hence it is more confidered by fome Roman writers as a part of Phrygia, than Bithynia, Cappado-

Phrygia.

cia, or any other of the adjacent provinces. In after ages, the Greater Phrygia was divided into two diſtricts or governments; one called Phrygia Pacatiana, from Pacatianus, who, under Conſtantine, bore the great office of the præfectus prætorio of the Eaſt; the other Phrygia Salutaris, from ſome miraculous cures ſuppoſed to have been performed there by the archangel Michael.

This country, and indeed all Aſia Minor, as lying in the fifth and ſixth northern climates, was in ancient times greatly celebrated for its fertility. It abounded in all ſorts of grain; being, for the moſt part, a plain country covered with a deep rich ſoil, and plentifully watered by ſmall rivers. It was in ſome parts productive of bitumen and other combuſtible ſubſtances. It was well ſtocked with cattle, having large plains and paſture grounds. The air was anciently deemed moſt pure and wholeſome, though it is now in ſome parts thought extremely groſs, great part of the country lying uncultivated.

In Phrygia Major were anciently ſeveral cities of great celebrity; ſuch as APANEA, LAODICEA, HIERAPOLIS, Gordium, &c.—There were alſo ſome famous rivers; ſuch as Marſyas, Mæander, &c. The Mæander is now called *Madre* or *Mindre*, and was much celebrated by the ancients for its windings and turnings; from whence all ſuch windings and turnings have been denominated *mæanders*.

The Phrygians accounted themſelves the moſt ancient people in the world. Their origin, however, is extremely dark and uncertain. Joſephus and St Jerome ſay, they were deſcended from Togarmah, one of Gomer's ſons; and that they were known to the Hebrews under the name of Tigrammanes. The Heathen authors derive them from the Brygians, a people of Macedonia. But this is but mere conjecture; and it is a conjecture totally unſupported, except by the ſimilarity of names. Bochart thinks that the Phrygians were the offspring of Gomer the eldeſt ſon of Japhet; the word Phrygia being the Greek tranſlation of his name. Joſephus makes Gomer the father of the Galatians; but he, by the Galatians, muſt neceſſarily mean the Phrygians inhabiting that part of Phrygia which the Galatians had made themſelves maſters of; the deſcendants of Gomer being placed by Ezekiel northward of Judæa, near Togarmah (which Bochart takes to be Cappadocia), long before the Gauls paſſed over into Aſia. We are willing to let Gomer enjoy the fine country which Bochart is pleaſed to give him, and allow him the honour of being the progenitor of the Phrygians, ſince we know no other perſon on whom it can be conferred with any degree of probability.

The ancient Phrygians are deſcribed as ſuperſtitious, voluptuous, and effeminate, without any prudence or foreſight, and of ſuch a ſervile temper, that nothing but ſtripes and ill uſage could make them comply with their duty; which gave riſe to ſeveral trite and well known proverbs (A). They are ſaid to have been the firſt inventors of divination by the ſinging, flying, and feeding of birds. Their muſic, commonly called the *Phrygian mood*, is alleged by ſome as an argument of their effeminacy.

Phrygia.

This government was certainly monarchical; for all Phrygia was, during the reigns of ſome kings, ſubject to one prince. Ninnacus, Midas, Manis, Gordius, and his deſcendants, were undoubtedly ſovereigns of all Phrygia. But ſome time before the Trojan war, we find this country divided into ſeveral petty kingdoms, and read of divers princes reigning at the ſame time. Apollodorus mentions a king of Phrygia contemporary with Ilus king of Troy. Cedrenus and others ſpeak of one Teuthrans, king of a ſmall country in Phrygia, whoſe territories were ravaged by Ajax, himſelf ſlain in ſingle combat, his royal ſeat laid in aſhes, and his daughter, by name Tecmeſſa, carried away captive by the conqueror. Homer makes mention of Phoreys and Aſcanius, both princes and leaders of the Phrygian auxiliaries that came to the relief of Troy. Tantalus was king of Sipylus only, and its diſtrict; a prince no leſs famous for his great wealth, than infamous for his covetouſneſs and other deteſtable vices. That Phrygia was ſubdued either by Ninus, as Diodorus Siculus informs us, or by the Amazons, as we read in Suidas, is not ſufficiently warranted. Moſt authors that ſpeak of Gordius tell us, that the Phrygians having ſent to conſult an oracle in order to know how they might put an end to the inteſtine broils which rent their country into many factions and parties, received for anſwer, that the moſt effectual means to deliver themſelves and their country from the calamities they groaned under, was to commit the government to a king. This advice they followed accordingly, and placed Gordius on the throne.

Apamea was the chief emporium of all Aſia Minor. —Thither reſorted merchants and traders from all parts of Greece, Italy, and the neighbouring iſlands. Beſides, we know from Syncellus, that the Phrygians were for ſome time maſters of the ſea; and none but trading nations ever prevailed on that element. The country produced many choice and uſeful commodities, which afforded conſiderable exports. They had a ſafe coaſt, convenient harbours, and whatever may incline us to think that they carried on a conſiderable trade. But as moſt of the Phrygian records are loſt, we will not dwell on conjectures ſo difficult to be aſcertained.

We have no ſet form of their laws; and as to their learning, ſince we are told that for ſome time they enjoyed the ſovereignty of the ſea, we may at leaſt allow them a competent ſkill in geography, geometry, and aſtronomy; and add to theſe, from what we have ſaid above, a more than ordinary knowledge of muſic.

Some have been of opinion that the Phrygian language bore a great reſemblance to the Greek; but the

(A) "Phryges ſero ſapiunt, Phryx verberatus melior, Phryx non minus quam Spyntharus, &c.:" which proverbs intimate their ſervile temper; and ſhow that they were more fit to bewail misfortunes in an unmanly manner, than to prevent them by proper meaſures. Their muſic, too, was ſuited to their effeminate temper. The Doric mood was a kind of grave and ſolid muſic; the Lydian a doleful and lamentable harmony; but the Phrygian chiefly calculated to effeminate and enervate the mind. But this character is contradicted by others.

the contrary is manifest from the few Phrygian words which have been transmitted to us, and carefully collected by Bochart and Rudbechius. To these we may add the authority of Strabo, who, after attempting to derive the name of a Phrygian city from the Greek, concludes, that it is a difficult matter to discover any similitude between the barbarous words of the Phrygian language and the Greek. The Phrygian tongue, after the experiment made by Psammetichus king of Egypt, was looked upon by the Egyptians as the most ancient language of the world. But other nations, particularly the Scythians, refused to submit to their opinion, as founded on an argument of no real weight. "As the two children (say they) had never heard the voice of any human creature, the word *bec*, or *bekkos*, the first they uttered, was only an imitation of the goats that had suckled them, and happened to be a Phrygian word signifying *bread* (B).

We have already said, that the Phrygians were superstitious; their idols were consequently very numerous. The chief of these was Cybele, who went by a variety of names. (See CYBELE). They also worshipped Bacchus under the name of *Sabazios*; and his priests they called *Saboi*.

The history of their kings is dark and uncertain, and the dates of their several reigns and actions cannot now be fixed; we shall refer such of our readers, therefore, as wish to know what is certain respecting them, to the Ancient Universal History, already quoted more than once in the present article. See also GORDIUS, MIDAS, &c. For Phrygia Minor, see TROY.

PHRYGIAN STONE, in *Natural History*, is the name of a stone described by the ancients, and used by them in dyeing; perhaps from some vitriolic or aluminous salt contained in it, which served to enliven or fix the colours used by the dyers. It was light and spungy, resembling a pumice; and the whitest and lightest were reckoned the best. Pliny gives an account of the method of preparing it for the purpose of dyeing, which was by moistening it with urine, and then heating it red hot, and suffering it to cool.—This calcination was repeated three times, and the stone was then fit for use. Dioscorides recommends it in medicine after burning; he says it was drying and astringent.

PHRYGIANS, a Christian sect. See CATAPHRYGIANS and MONTANISTS.

PHRYNE, was a famous prostitute, who flourished at Athens about 328 years before the Christian era. She was mistress of Praxiteles, who drew her picture, which was one of his best pieces, and was placed in the temple of Apollo at Delphi. We are told that Apelles painted his Venus Anadyomene after he had seen Phryne on the sea-shore naked, and with dishevelled hair. Phryne became so very rich by the liberality of her lovers, that she offered to rebuild Thebes at her own expence, which Alexander had destroyed, provided this inscription was placed on the walls: *Alexander diruit, sed meretrix Phryne refecit*; which was refused. See *Plin.* 34. c. 8.——There was another of the same name who was accused of impiety. When she found that she was going to be condemned, she unveiled her bosom, which so influenced her judges, that she was immediately acquitted.

PHRYNICUS, a general of Samos, who endeavoured to betray his country, &c.——A flatterer at Athens. ——A tragic poet of Athens, disciple to Thespis. He was the first who introduced a female character on the stage.

PHRYNIS was a musician of Mitylene. He was the first who obtained a musical prize at the Panathenæa at Athens. He added two strings to the lyre, which had always been used with seven by all his predecessors. He flourished about 438 years before the Christian era. We are told that he was originally a cook at the house of Hiero king of Sicily.——There was another of the same name, a writer in the reign of Commodus, who made a collection, in 36 books, of phrases and sentences from the best Greek authors, &c.

PHRYXUS, in fabulous history, was a son of Athamas king of Thebes, by Nephele. When his mother was repudiated, he was persecuted with the most inveterate fury by his step-mother Ino, because he was to sit on the throne of Athamas, in preference to the children of a second wife. His mother apprized him of Ino's intentions upon his life; or, according to others, his preceptor; and the better to make his escape, he secured part of his father's treasures, and privately left Bœotia with his sister Helle, to go to their friend and relation Æetes king of Colchis. They embarked on board a ship, or, as we are informed by the fabulous account of the poets and mythologists, they mounted on the back of a ram, whose fleece was of gold; and proceeded on their journey through the air. The height to which they were carried made Helle giddy, and she fell into the sea. Phryxus gave his sister a decent burial on the sea-shore, and after he had called the place *Hellespont* from her name, he continued his flight, and arrived safe in the kingdom of Æetes, where he offered the ram on the altars of Mars. The king received him with great tenderness, and gave him Chalciope his daughter in marriage. She had by him Phrontis Melas, Argos Cylindrus, whom some call *Cytorus*. He was afterwards murdered by his father-in-law, who envied him the possession of the golden fleece; and Chalciope, to prevent her children from sharing their father's fate, sent them privately from Colchis to Bœotia, as nothing was to be dreaded there from the jealousy or resentment of Ino, who was then dead. The fable of the flight of Phryxus to Colchis on a ram has been explained by some, who observe, that the ship on which he embarked was either called by that name, or carried on her prow a figure of that animal. The fleece of gold is accounted for, by observing that Phryxus carried away immense treasures from Thebes. Phryxus was placed among the constellations of heaven after death. The ram which carried him to Asia is said to have been the fruit of Neptune's amour with Theophane the daughter of Altis. This ram the gods had given to Athamas in order to reward his piety and religious life; and Nephele procured it for her

(B) Goropius Becanus makes use of the same argment, to prove that the High Dutch is the original or mother-tongue of the world, because the word *beker* in that language signifies "a baker."

her children, just as they were going to be sacrificed to the jealousy of Ino. Phryxus's murder was some time after amply revenged by the Greeks; it having occasioned the famous expedition atchieved under Jason and many of the princes of Greece, which had for its object the recovery of the golden fleece, and the punishment of the king of Colchis for his cruelty to the son of Athamas.

PHTHIRIASIS, the LOUSY EVIL, from φθειρ, "a louse." Children are frequently its subjects, but adults are sometimes troubled with it. The increase of lice, when in a warm moist situation, is very great; but a cold and dry one soon destroys them. On the human body four kinds of lice are distinguished: 1. The *pediculi*, so called because they are more troublesome with their feet than by their bite. These are in the heads of children, especially if sore or scabby; and often in those of adults, if they are slothful and nasty. 2. Crab-lice. 3. Body lice; these infest the body, and breed in the clothes of the nasty and slothful. 4. A sort which breed under the cuticle, and are found in the hands and feet: they are of a round form, and so minute as often to escape the sight: by creeping under the scarf-skin they cause an intolerable itching; and when the skin bursts where they lodge, clusters of them are found there. See ACARUS.

A good diet and cleanliness conduce much to the destruction of lice. When they are in the head, comb it every day; and, after each combing, sprinkle the pulv. sem. staph. agr. or coccul. Ind. among the hairs every night, and confine it with a tight cap.

Codrochius, in his treatise on lice, says, that the powdered coc. Ind. exceeds all other means; and that it may be mixed in the pulp of apple, or in lard, and applied every night to the hair. Some writers assert, that if the pulv. cort. rad. sassafr. be sprinkled on the head, and confined with a handkerchief, it destroys the lice in one night.

The body-lice are destroyed by any bitter, sour, salt, or mercurial medicine, if applied to the skin.

Black soap, and the flowers called *cardamine* or *lady's smock*, are said to be specifics in all cases of lice on the human body.

PHTHISIS, a species of consumption, occasioned by an ulcer in the lungs. See MEDICINE *Index*.

PHUL, or PUL, king of Assyria, is by some historians said to be Ninus under another name, and the first founder of that monarchy: A renowned warrior. He invaded Israel in the reign of Menahem, who became tributary to him, and paid him 1000 talents of silver for a peace. Flourished 771 B. C.

PHUT, or PHUTH, the third son of Ham (Gen. x. 6.). Calmet is of opinion, that Phut peopled either the canton of Phtemphu, Phtemphuti, or Phtembuti, set down in Pliny and Ptolemy, whose capital was Thara in Lower Egypt, inclining towards Libya; or the canton called Phtenotes, of which Buthus was the capital. The prophets often speak of Phut. In the time of Jeremiah, Phut was under the obedience of Necho king of Egypt. Nahum (iii. 9.) reckons up his people in the number of those who ought to have come to the assistance of No-ammon or Diospolis.

PHYLACTERY, in the general, was a name given by the ancients to all kinds of charms, spells, or characters, which they wore about them, as amulets, to preserve them from dangers or diseases.

PHYLACTERY particularly denoted a slip of parchment, wherein was written some text of Holy Scripture, particularly of the decalogue, which the more devout people among the Jews wore on the forehead, the breast, or the neck, as a mark of their religion.

The primitive Christians also gave the name *phylacteries* to the cases wherein they inclosed the relicks of their dead.

Phylacteries are often mentioned in the New Testament, and appear to have been very common among the Pharisees in our Lord's time.

PHYLICA, BASTARD ALATERNUS; a genus of plants belonging to the pentandria class. See BOTANY *Index*.

PHYLLANTHUS, SEA-SIDE LAUREL; a genus of plants belonging to the monœcia class. See BOTANY *Index*.

PHYLLIS, in fabulous history, was a daughter of Sithon, or, according to others, of Lycurgus king of Thrace, who received Demophoon the son of Theseus; who, at his return from the Trojan war, had stopped on her coasts. She became enamoured of him, and did not find him insensible to her passion. After some months of mutual tenderness and affection, Demophoon set sail for Athens, where his domestic affairs recalled him. He promised faithfully to return as soon as a month was expired; but either his dislike for Phyllis, or the irreparable situation of his affairs, obliged him to violate his engagement: and the queen, grown desperate on account of his absence, hanged herself, or, according to others, threw herself down a precipice into the sea and perished. Her friends raised a tomb over her body, where there grew up certain trees, whose leaves, at a particular season of the year, suddenly became wet as if shedding tears for the death of Phyllis. According to an old tradition mentioned by Servius, Virgil's commentator, Phyllis was changed by the gods into an almond tree, which is called *phylla* by the Greeks. Some days after this metamorphosis, Demophoon revisited Thrace; and when he heard of the fate of Phyllis, he ran and clasped the tree, which, though at that time stripped of its leaves, suddenly shot forth, and blossomed as if still sensible of tenderness and love. The absence of Demophoon from the house of Phyllis has given rise to a beautiful epistle of Ovid, supposed to have been written by the Thracian queen about the fourth month after her lover's departure.—A country woman introduced in Virgil's eclogues.—The nurse of the emperor Domitian.—A country of Thrace near Mount Pangæus.

PHYSALIS, the WINTER CHERRY; a genus of plants belonging to the pentandria class. See BOTANY *Index*.

PHYSETER, or SPERMACETI WHALE, a genus belonging to the order of cete. See CETOLOGY *Index*.

PHYSIC, or PHYSICK, the art of healing; properly called MEDICINE. The word is formed from the Greek φυσις, "nature;" in regard medicine consists principally in the observation of nature. See PHYSICS and MEDICINE.

PHYSICAL, something belonging to, or really existing

Physician. existing in, nature. In this sense we say a physical point, in opposition to a mathematical one, which only exists in the imagination; a physical substance or body, in opposition to spirit, or metaphysical substance, &c.

PHYSICIAN, a person who professes medicine, or the art of healing diseases. See MEDICINE.

PHYSICIANS, College of, in London, Edinburgh, and Dublin. See COLLEGE *of Physicians.* Physicians, Physico-mathematics.

PHYSICO-MATHEMATICS, includes those branches of physics which, uniting observation and experiment to mathematical calculation, undertake to explain the phenomena of nature.

PHYSICS,

1 General definition of physics.

TAKEN in its most enlarged sense, comprehends the whole study of nature; and NATURAL PHILOSOPHY is a term of the same extent: but ordinary language, and especially in this country, employs both of these terms in a much narrower sense, which it is proper in this place to determine with some precision.

2 A more particular explanation of the term.

Under the article PHILOSOPHY, we gave a particular account of that view of nature in which the objects of our attention are considered as connected by causation; and we were at some pains to point out the manner in which this study may be successfully cultivated. By a judicious employment of the means pointed out in that article, we discover that the objects of our contemplation compose an UNIVERSE, which consists, not of a number of independent existences solitary and detached from each other, but of a number of substances connected by a variety of relations and dependencies, so as to form a whole which may with great propriety be called the SYSTEM OF NATURE.

This assembling of the individual objects which compose the universe into one system is by no means the work of a hasty and warm fancy, but is the result of sober contemplation. The natural historian attempts in vain to describe objects, by only informing us of their shape, colour, and other sensible qualities. He finds himself obliged, in describing a piece of marble, for instance, to tell us that it takes a fine polish; that it strikes fire with steel; that it burns to quicklime, that it dissolves in aquafortis, and is precipitated by alkalies; that with vitriolic acid it makes gypsum, &c. &c. &c. and thus it appears that even the *description* of any thing, with the view of ascertaining its specific nature, and with the sole purpose of discrimination, cannot be accomplished without taking notice of its various relations to other things. But what do we mean by the *nature* of any thing? We are ignorant of its essence, or what makes it that thing and no other thing. We must content ourselves with the discovery of its *qualities* or *properties*; and it is the assemblage of these which we call its *nature*. But this is very inaccurate. These do not constitute its essence, but are the consequences of it. Yet this is all we shall ever know of its nature. Now the term *property* is nothing but a name expressing some relation which the substance under consideration has to other things. This is true of all such terms. Gravity, elasticity, sensibility, gratitude, and the like, express nothing but certain *matters of fact*, which may be observed respecting the object of our contemplation in different circumstances of situation with regard to other things. Our distinct notions of individuals, therefore, imply their relations to other things.

The slightest observation of the universe shows an evident connection between all its parts in their various properties. All things on this earth are connected with each other by the laws of motion and of mind. We are connected with the whole of the solar system by gravitation. If we extend our observations to the fixed stars, the connection seems to fail; but even here it may be observed. Their inconceivable distance, it is true, renders it impossible for us to obtain any *extensive* information as to their nature. But these bodies are connected with the solar system by the sameness of the light which they emit with that emitted by our sun or any shining body. It moves with the same velocity, it consists (in most of them at least) of the same colours, and it is reflected, refracted, and inflected, according to the same laws.

3 All parts of the universe evidently connected in their various properties.

4 Our attention naturally directed in the first instance to our fellow men.

In this unbounded scene of contemplation, our attention will be directed to the different classes of objects nearly in proportion to the interest we take in them. There is nothing in which we are so much interested as our fellow men; and one of the first steps that we make in our knowledge of nature, is an acquaintance with them. We learn their *distinctive* nature by attending to their *characteristic* appearances; that is, by observing their actions. We observe them continually producing, like ourselves, certain changes in the situation or condition of surrounding objects; and these changes are evidently directed to certain ends *which respect themselves*. Observing this subserviency of the effects which they produce to their own accommodation, we consider this adjustment of means to ends as the effect of an INTENTION, as we experience it to be in our own case, where we are conscious of this intention, and of these its effects. We therefore interpret those actions of other men, where we observe this adjustment of means to ends, as marks or signs of intention in them similar to our own. And thus a quality, or power, or faculty, is *supposed* in them *by means of its sign*, although the quality itself is not *immediately* cognisable by our senses. And as this intention in ourselves is accompanied by perception of external objects, knowledge of their properties, desire of good, aversion from evil, volition, and exertion, without all of which we could not or would not perform the actions which we daily perform, we *suppose* the same perception, knowledge, desire, aversion, volition, and exertion in them.

5 Nature of intention.

Thus, by the constitution of our mind, we consider the employment of means, by which ends terminating in the agent are gained, as the natural signs of design or intention. ART, therefore, or the employment of means, is the natural sign of intention; and wherever we observe this adjustment of means to ends, we infer the agency of design.

A small acquaintance with the objects around us, obliges us to extend this inference to a great number of beings besides our fellow men, namely, to the whole animal

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animal creation: for in all we obſerve the ſame ſubſerviency to the ends of the agent, in the changes which we find them continually producing in the objects around them. Theſe changes are all adjuſted to their own well-being. In all ſuch caſes, therefore, we are forced, by the conſtitution of our own minds, to infer the exiſtence of deſign or intention in theſe beings alſo.

But in numberleſs changes produced by external objects on each other, we obſerve no ſuch fitneſs in the effects, no ſuch ſubſerviency to the well-being of the agent. In ſuch caſes, therefore, we make no ſuch inference of thought or deſign.

6 All objects divided into thinking and unthinking beings.

Thus, then, there is preſented to our obſervation an important diſtinction, by which we arrange all external objects into two claſſes. The firſt reſembles ourſelves, in giving external marks of that thought or intention of which we are conſcious; and we *ſuppoſe* in them the other properties which we diſcover in ourſelves, but cannot *immediately* obſerve in them, viz. thought, perception, memory, foreſight, and all that collection of faculties which we feel in ourſelves, and which conſtitute the animal. The other claſs of objects exhibits no ſuch appearances, and we make no ſuch inference. And thus we divide the whole of external nature into the claſſes of THINKING and UNTHINKING beings.

7 How we come to the knowledge of mind.

Our firſt judgements about theſe claſſes will be very inaccurate; and we will naturally aſcribe the differences, which we do not very well underſtand, to the differences in organical ſtructure, which we clearly obſerve. But when we have knocked down or perhaps ſmothered an animal, we find that it no longer gives the former marks of thought and intention, and that it now reſembles the claſs of unthinking beings: And yet it ſtill retains all that fitneſs of organical ſtructure which it had before; it ſeems only to want the intention and the will. This obliges us to conclude that the diſtinction does not ariſe from a difference in organical ſtructure, but from a diſtinct ſubſtance common to all thinking beings, but ſeparable from their organical frame. To this ſubſtance we aſcribe thought, intention, contrivance, and all that collection of faculties which we feel in ourſelves. To this ſubſtance in ourſelves we refer all ſenſations, pleaſures, pains, remembrances, deſires, purpoſes; and to this aggregate, however imperfectly underſtood, we give the name MIND. Our organical frame, which ſeems to be only the inſtrument of information and operation to the mind, we call *our* body.

8 The nature of mind as underſtood by mankind in rude ages.

As the animating principle is not, like our body, the immediate object of the ſenſes, we naturally conceive it to be a ſubſtance eſſentially different from thoſe which are the objects of our ſenſes. The rudeſt people have ſhown a diſpoſition to form this concluſion. Obſerving that animal life was connected with breathing, it was natural to imagine that breathing was living, and that breath was life. It is a remarkable fact, that in moſt languages the term for expreſſing *breath* is at leaſt one of the terms for expreſſing the ſoul; רוח, *πνευμα*, *ſpiritus*, in the Hebrew, Greek, and Latin, expreſs both; *gheiſt*, or *ghoſt*, in the Teutonic, comes from *gheiſen*, to "breathe or ſigh;" *dŭcha* or *dūha*, "the ſoul," in Sclavonic, comes from *duichat*, "to breathe;" ſo in the Gaelic does *anal* come from *anam;* and the ſame relation is found between the two words in the Malay and other eaſtern languages. We believe that moſt perſons can recollect ſome traces of this notion in their early conceptions of things; and many who do not conſider themſelves as uncultivated, believe that the ſoul quits the body *along with the laſt breath*. Among the Tartar nations hanging is conſidered with particular horror, on account of the ungraceful and filthy exit which the ſoul is obliged to make from the body.

9 Their opinions not juſt.

But the obſervation of the ſame appearances of thought and intention in fiſhes and other animals which do not breathe, would ſoon ſhow that this was but a rude conception. Very little refinement indeed is neceſſary to convince us that air or breath cannot be the ſubſtance which thinks, wiſhes, and deſigns; and that the properties of this ſubſtance, whatever it is, muſt be totally different from, and incompatible with, any thing that we know of the immediate objects of our ſenſes.

10 Of the two kinds of ſubſtances in nature, one is the object of reflection alone, the other of the ſenſes.

Hence we are led to conclude that there are two kinds of ſubſtances in nature: One, which is the principle of ſenſation; and therefore *cannot* be the object of our ſenſes, any more than light can be the object of the microſcope. This ſubſtance alone can feel, think, deſire, and propoſe, and is the object of *reflection alone*. The objects of our ſenſes compoſe the other claſs, and therefore can have none of the other properties which are not cognoſcible by the ſenſes. Theſe have all the properties which our ſenſes can diſcover; and we can have no evidence of their having any other, nor indeed any conception of their having them. This claſs is not confined to the unorganized maſſes of matter; for we ſee that the bodies of animals loſe after death that organical form, and are aſſimilated to all the reſt of unthinking beings. It has ariſen from ſuch views as this, that while all nations have agreed to call this claſs of objects by the name BODY, which originally expreſſes our organical frame, ſome nations, farther advanced in cultivation or refinement, have contrived an abſtract term to expreſs this general ſubſtance of which all inanimate beings are compoſed. Such a term we have in the words *materies*, *ὑλη*.

11 The diſtinction between material and immaterial ſubſtances is very important.

Matter, then, is that ſubſtance which is immediately cognoſcible by our ſenſes. Whatever, therefore, is not thus immediately cognoſcible by our ſenſes is not material, and is expreſſed by a negative term, and called *immaterial:* hence it is that mind is ſaid to be immaterial. It is of importance to keep in mind this diſtinction, merely grammatical. Little more is neceſſary for detecting the ſophiſms of Helvetius, Mirabeau, and other ſages of the Gallic ſchool, who have been anxious to remove the ties of moral and religious obligation by lowering our conceptions of our intellectual nature. It will alſo ſerve to ſhow how haſtily *they* have formed their opinions who have aſcribed to the immediate agency of mind all thoſe relations which are obſerved in the actions of bodies on each other at a diſtance. The connecting principles of ſuch relations *è diſtante* (if there be any ſuch), are not the immediate objects of our ſenſes: they are therefore immaterial. But it does not follow that they are minds. There may be many immaterial ſubſtances which are not minds. We know nothing of any object whatever but by the obſervation of certain appearances, which ſuggeſt to our minds the exiſtence and agency of its qualities or powers. Such phenomena are the natural ſigns of theſe qualities, and it is to thoſe ſigns that we muſt always have recourſe when we wiſh to conceive

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conceive without ambiguity concerning them. What is the characteriſtic phenomenon of mind, or what is the *diſtinguiſhing* quality which brings it into view? It is INTENTION: and it may be aſſerted with the utmoſt confidence, that we have no other mark by which mind is immediately ſuggeſted to us, or that would ever have made us ſuppoſe that there exiſted another mind beſides our own. The *phenomenon* by which this quality is ſuggeſted to us is *art*, or the employment of means to gain ends; and the mark of art is the ſuppoſed conduciveneſs of theſe ends to the well-being of the agent. Where this train is not obſerved, deſign or intention is never thought of; and therefore where intention is not perceived in any immaterial ſubſtance, if any ſuch has ever been obſerved, it is an abuſe of language to call it mind. We do not think that even perception and intelligence entitle us to give the name mind to the ſubſtance in which they are inherent, becauſe it is from marks of intention alone that we infer the exiſtence of mind; and although theſe muſt be accompanied with perception and intelligence, it does not follow that the ſubſtance which can perceive and underſtand muſt alſo deſire and propoſe. However difficult we may find it to ſeparate them, they are evidently ſeparable in imagination. And let not this aſſertion be too haſtily objected to; for the ſeparation *has been made* by perſons moſt eminent for their knowledge and diſcernment. When Leibnitz aſcribed to his MONADES, or what we call the ultimate ATOMS of matter, a perception of their ſituation in the univerſe, and a motion preciſely ſuited to this perception, he was the fartheſt in the world from ſuppoſing them animated or endowed with minds. It is true indeed, that others, who think and call themſelves philoſophers, are much more liberal in their application of this term. A modern author of great metaphyſical eminence ſays, "I call that *mind* which moves, and that *body* which is moved." This claſs of philoſophers aſſert that no motion whatever is begun except by the agency of an animating principle, which (after Ariſtotle) they call *Nature*, and which has in theſe days been exalted to the rank of a god. All this jargon (for it is nothing elſe) has ariſen from the puzzle in which naturaliſts think themſelves involved in attempting to explain the production of motion in a body at a diſtance from that body which is conceived as the cauſe of this motion. After having been reluctantly obliged, by the reaſonings of Newton, to abandon their methods of explaining ſuch phenomena by the impulſes of an intervening fluid, nothing ſeemed left but the aſſertion that theſe motions were produced by minds, as in the caſe of our own exertions. Theſe explanations (if they deſerve the name) cannot be objected to in any other way than as an abuſe of language, and as the introduction of an unmeaning jargon. We have, and can have, no notion of mind different from thoſe of our own minds; and we diſcover the exiſtence of other minds as we diſcover the exiſtence of bodies, by means of phenomena which are characteriſtic of minds, that is, which reſemble thoſe phenomena that follow the exertion of our own mental faculties, that is, by the employment of means to attain ſelfiſh ends; and where ſuch appearances are not obſerved, no exiſtence of a mind is inferred. When we ſee a man fall from the top of a houſe, and daſh out his brains on the pavement, we never aſcribe this motion to his mind. Although the fitneſs of many of the celeſtial motions for moſt important purpoſes makes us ſuppoſe deſign and contrivance ſomewhere, and therefore a *Supreme Mind*, we no more think of inferring a mind in the earth from the fitneſs of its motions for purpoſes moſt beneficial to its inhabitants, than of inferring a mind in a bit of bread from its fitneſs for nouriſhing our bodies. It is not from the mere motions of animals that their minds are inferred, but from the conduciveneſs of theſe motions to the well-being of the animal.

12 The mind is not that which produces motion, but that which deſires and wills.

The term mind therefore, in the *ordinary language* of all men, is applied to what deſires and wills at the ſame time that it perceives and underſtands. If we call that mind which *produces motion*, we muſt derive our notions of its qualities or attributes from obſerving their effects. We muſt therefore diſcover the general laws by which they act, that is, the general laws obſerved in thoſe motions which we conſider as their effects. Now theſe are the general laws of motion; and in none of theſe can we find the leaſt coincidence with what we are accuſtomed to call the laws of mind. Nay, it has been the total want of ſimilarity which has given riſe to the diſtinction which all men, in all ages and countries, have made between mind and matter. This diſtinction is found in all languages; and it is an unpardonable liberty which men take with language when they uſe a *term of diſtinction*, a *ſpecific term*, to expreſs things of a different ſpecies. What theſe authors have been pleaſed to call *mind*, the whole world beſides have called by another name, FORCE; which, though borrowed from our own exertions, is yet ſufficiently diſtinctive, and never leads us to confound things that are different, except in the language of ſome modern philoſophers, who apply it to the laws of the agency of mind; and, when ſpeaking of the force of motives, &c. commit the ſame miſtakes which the followers of Ariſtotle commit in the uſe of the term mind. *Force*, in the language of theſe philoſophers, means what connects the operations of mind; as mind, in the language of Lord Monboddo, is that which connects the operations of body.

13 The principle of motion not diſtinct from matter and mind.

Thoſe are not leſs to blame who conſider this *Nature* of Ariſtotle, this principle of motion, as an exiſtence or ſubſtance different both from matter and from the minds of intelligent creatures. Ariſtotle calls it in ſome places ὥσπερ ψυχή. He might with equal propriety, and equal conſiſtency with his other doctrines, have called mind, ὥσπερ τέλος, or an ὥσπερ δύναμις. Beſides, we have no evidence for the ſeparability of this ὥσπερ ψυχή from body as we have for the ſeparability of ſuch minds as our own, the genuine ψυχαί. Nay, his whole doctrines, when maturely conſidered, aſſume their abſolute inſeparability.

14 Elemental minds are an abuſe of language.

This doctrine of elemental minds, therefore, as the immediate cauſes of the phenomena of the material world, is an abuſe of language. It is a jargon; and it is a frivolous abuſe, for it offers no explanation whatever. The phenomena are totally unlike the phenomena of ordinary minds, and therefore receive no explanation from them; and ſince our knowledge of theſe *quaſi* minds muſt be derived entirely from the phenomena, it will be preciſely the ſame, although we expreſs it in common language. We ſhall not indeed raiſe the wonder of our hearers, as thoſe do who fill the world with minds which they never ſuſpected to exiſt; but we ſhall

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not bewilder their imaginations, confound their ideas, and miſlead their judgements.

15 The dreadful conſequences of materialiſm.

We flatter ourſelves that our readers will not think theſe obſervations unſeaſonable or miſplaced. Of all miſtakes that the naturaliſt can fall into, there is none more fatal to his progreſs in knowledge than the confounding things which are eſſentially different; and of all the diſtinctions which can be made among the objects of our contemplation, there is none of equal philoſophical importance with this between mind and matter: And when we conſider the conſequences which naturally follow from this confuſion of ideas, and particularly thoſe which follow from ſinking the mental faculties of man to a level with the operations of mechanics or chemiſtry, conſequences which the experience of the preſent eventful day ſhows to be deſtructive of all that is noble or deſirable in human nature, and of all that is comfortable in this life, and which blaſts every hope of future excellence—we cannot be too anxious to have this capital diſtinction put in the plaineſt point of view, and expreſſed in the moſt familiar characters, "ſo that he who runneth may read." When we ſee the frenzy which the reaſoning pride of man has raiſed in our neighbourhood, and hear the dictates of philoſophy inceſſantly appealed to in defence of whatever our hearts ſhudder at as ſhocking and abominable; and when we ſee a man (A), of great reputation as a naturaliſt, and of profeſſed humanity and political moderation, congratulating his countrymen on the rapid improvement and almoſt perfection of philoſophy; and after giving a ſhort ſketch of the conſtitution of the viſible univerſe, ſumming up all with a table of elective attractions, and that particular combination and mode of cryſtallization which conſtitutes GOD (*horreſco referens!*)—is it not full time for us to ſtop ſhort, and to aſk our own hearts "whither are you wandering?"—But ſound philoſophy, reaſoning from effects to their cauſes, will here liſten to the words of our ſacred oracles: "By their fruits ye ſhall know them. Do men gather grapes of thorns, or figs of thiſtles?" The abſurd conſequences of the ſceptical philoſophy of Berkeley and Hume have been thought, by men of undoubted diſcernment, ſufficient reaſons for rejecting it without examination. The no leſs abſurd and the ſhocking conſequences of the mechanical philoſophy now in vogue ſhould give us the ſame abhorrence; and ſhould make us abandon its blood-ſtained road, and return to the delightful paths of nature, to ſurvey the works of God, and feaſt our eyes with the diſplays of mind, which offer themſelves on every hand in deſigns of the moſt extenſive influence and the moſt beautiful contrivance. Following the guidance of heavenly wiſdom, we ſhall indeed find, that "all her ways are ways of pleaſantneſs, and all her paths are peace."

16 The extent of philoſophical ſtudy.

Such is the ſcene of our obſervation, the ſubject of philoſophical ſtudy. Its extent is almoſt unbounded, reaching from an atom to God himſelf. It is abſolutely neceſſary for the ſucceſsful cultivation of this immenſe field of knowledge, that it be committed to the care of different cultivators, and that its various portions be treated in different ways: and, accordingly, the various taſtes of men have given this curioſity different directions; and the ſtudy, like all other taſks, has been promoted by this diviſion of labour.

Some philoſophers have attended only to the appearances of fitneſs which are exhibited in every quarter of the univerſe; and by arranging theſe into different claſſes, and interpreting them as indications of thought aad intention, have acquired the knowledge of many claſſes of ſentient and intelligent beings, actuated by propenſities, and directed by reaſon.

17 The nature and uſes of animal inſtincts.

While the contemplation of theſe appearances indicates thought and deſign in any individual of one of theſe claſſes, and brings its propenſities and purpoſes of action, and the ends gained by theſe actions, into view, the contemplation of theſe propenſities, purpoſes, and ends, occaſions an inference of a much more general kind. All theſe intelligent beings give indications of knowledge and of power; but their knowledge bears, in general, no proportion to their power of producing changes in nature, and of attaining important ends; and their power is neither always, nor in the moſt important caſes, the conſequence of their knowledge. Where the effect of their actions is moſt eminently conducive to their important intereſts, the power of attaining theſe valuable ends is generally independent on any attention to the fitneſs of the means, and the exertion is frequently made without even thinking of the important end. The well-being of the individual is ſecured againſt any danger from its ignorance, indolence, or inattention, by an inſtinctive propenſity, which leads it to the performance of the neceſſary action, which is thus made immediately and ultimately deſirable, without any regard to its ultimate and important end. Thus, in our own nature, the ſupport of animal life, and the improvement of the means of ſubſiſtence by a knowledge of the objects which ſurround us, are not entruſted to our apprehenſions of the importance of theſe ends, but are committed to the ſurer guides of hunger and curioſity.

18 There is a connection between the individuals of a claſs of animals different from that of reſemblance.

The ſame obſervers diſcover a connection between the individuals of a claſs, different from that which ariſes from the mere reſemblance of their external appearance, or even of their propenſities and purſuits; the very circumſtances which produced the claſſification. They obſerve, that theſe propenſities are ſuch, that while each individual ſeeks only its own enjoyment, theſe enjoyments are in general ſuch as contribute to the ſupport of the ſpecies and the enjoyment of other individuals. Thus, in the claſſes of animals, and in human nature, the continuance of the race, and the enjoyment of the whole, are not entruſted to the apprehenſion we entertain of the importance of theſe ends, but are produced by the operation of ſexual love and the love of ſociety.

19 There is alſo a link of connection between ſentient beings of different claſſes.

The ſame obſervers find that even the *different* claſſes of ſentient beings are connected together; and while the whole of each claſs aim only at their own enjoyment, they contribute, in ſome way or other, to the well-being of the other claſſes. Even man, the ſelfiſh

lord

(A) M. de la Metherie, editor of the *Journal de Phyſique.* See his prefaces to the volumes for 1792 and 1793, January and July.

lord of this ſublunary world, is not the unconnected inhabitant of it. He cannot, in every inſtance, reap all the fruits of his ſituation, without contributing to the enjoyment of thouſands of the brute creation. Nay, it may be proved to the ſatisfaction of every intelligent man, that while one race of animals, in conſequence of its peculiar propenſities, ſubſiſts by the deſtruction of another, the ſum total of animal life and enjoyment is prodigiouſly increaſed. See a very judicious diſſertation on this curious and puzzling ſubject, entitled *A Philoſophical Survey of the Animal Creation;* where it appears that the increaſe of animal life and enjoyment which is produced by this means, beyond what could poſſibly obtain without it, is beyond all conception. See likewiſe the laſt edition of *King's Origin of Evil*, by Dr Law late biſhop of Carliſle.

20
The end of this connection is the accumulation of happineſs.

Thus the whole aſſemblage ſeems connected, and jointly employed in increaſing the ſum total of poſſible happineſs. This fitneſs of the various propenſities of ſentient and intelligent beings, this ſubſerviency to a general purpoſe, ſtrikes theſe obſervers as a mark of intention, evidently diſtinct from, and independent of, all the particular intentions, and ſuperior to them all; and thus it irreſiſtibly leads them to infer the exiſtence of a SUPREME MIND, directing the whole of this INTELLECTUAL SYSTEM, while the individuals of which it conſiſts appear the unconſcious inſtruments in the hand of a great Artiſt, with which he executes his grand and beneficent purpoſes.

21
All nature, animate and inanimate, thinking, and unthinking, is connected.

But the obſervation goes yet further. The bodies of the inanimate creation are not only connected with each other by a mutual dependence of properties, and the relation of cauſation, but they are alſo connected with the ſentient beings by a ſubſerviency to their purpoſes of enjoyment. The philoſopher obſerves that this connection is admirably kept up by the conſtancy of natural operations and the expectations of intelligent beings. Had either of theſe circumſtances been wanting, had either the operations of nature been without rule, or had ſentient beings no perception or expectation of their uniformity; the ſubſerviency would be totally at an end. This adjuſtment, this fitneſs, of which the effect is the enjoyment of the ſentient inhabitants of the univerſe, appear to be the effect of an intention of which this enjoyment is the final cauſe. This conſtancy therefore in the operations of nature, both in the intellectual and material world, and the concomitant expectation of ſentient beings, appear the effects of *laws* impoſed on the different parts of the univerſe by the Supreme Mind, who has formed both theſe claſſes of beings ſo admirably ſuited to each other.

22
The origin of natural theology.

To ſuch obſervers the world appears a WORK OF ART, a ſyſtem of means employed for gaining certain propoſed ends, and it carries the thoughts forward to an ARTIST; and we infer a degree of ſkill, power, and good intention in this Artiſt, proportioned to the ingenuity, extent, and happy effect which *we are able to diſcern* in his works. Such a contemplation of nature, therefore, terminates in NATURAL THEOLOGY, or the diſcovery of the exiſtence and attributes of GOD.

23
Our mode of reaſoning on the operations of God.

Our notions of this *Supreme Mind* are formed from the indications of deſign which we obſerve, and which we interpret in the ſame way as in the actions of men. Theſe notions, therefore, will differ from our notions of other minds only in the *degrees* which we *are able* to obſerve, and which we aſſign to theſe faculties; for the phenomenon or the effect is not only the mark, but alſo the meaſure of its ſuppoſed cauſe. Theſe degrees muſt be aſcertained by our own capacity of appreciating the extent, the multiplicity, and the variety of the contrivance. Accordingly, the attributes of the Supreme Mind, in the theological creed of a rude Indian, are much more limited than in that of a European philoſopher. In proportion as our underſtandings are enlarged, and as our acquaintance with the operations of nature around us is extended, we ſhall perceive higher degrees of power, of ſkill, and of kind intention: and ſince we find that the ſcene of obſervation is unbounded, we cannot affix any boundaries to theſe attributes in our own imagination, and we are ready to ſuppoſe that they are infinite or unbounded *in their own nature.* When our attentive ſurvey of *this* univerſe, and a careful compariſon of all its parts, as far as we can underſtand or appreciate them, have made us conclude that it is *one* deſign, the work of *one Artiſt;* we are under the neceſſity of inferring, that, with reſpect to *this univerſe*, his power, wiſdom, and benevolence, are indeed infinite.

24
The ſyſtem of nature is governed by general laws.

When men have been led to draw this concluſion from the appearances of fitneſs which are obſerved everywhere around them, they conſider that conſtancy which they obſerve in natural operations, whether in the material or the intellectual ſyſtem, and that expectation of, and confidence in, this conſtancy, which renders the univerſe a ſource of enjoyment to its ſentient inhabitants, as the conſequences of laws impoſed by the Almighty Artiſt on his works, in the ſame manner as they would conſider the conſtancy in the conduct of any people as the conſequences of laws promulgated and enforced by the ſupreme magiſtrate.

25
The nature and progreſs of the ſtudy of mind.

There can be no doubt of this view of nature being extremely captivating, and likely to engage the curioſity of ſpeculative men; and it is not ſurpriſing that the phenomena of mind have been keenly ſtudied in all ages. This part of the ſtudy of nature, like all others, was firſt cultivated in ſubſerviency to the wants of ſocial life; and the general laws of moral ſentiment were the firſt phenomena which were conſidered with attention.

26
The riſe of moral ſentiments and of moral duty.

This gradually ripened into a regular ſyſtem of moral duty, accompanied by its congenial ſtudy, the inveſtigation or determination of the *ſummum bonum*, or the conſtituents of human felicity; and theſe two branches of intellectual ſcience were always kept in a ſtate of aſſociation by the philoſophers of antiquity. Juriſprudence, the ſcience of government, legiſlation, and police, were alſo firſt cultivated as arts, or at leaſt in immediate ſubſerviency to the demands of cultivated ſociety; and all theſe ſo nearly related parts of the ſtudy of human nature, had made a very conſiderable progreſs, in the form of maxims or precepts for directing the conduct, before ſpeculative men, out of mere curioſity, treated them as ſubjects of philoſophical ſtudy. Our moral ſentiments, always involving a feeling of obligation, are expreſſed in a language conſiderably different from the uſual language of pure philoſophy, ſpeaking of things which *ought to be*, rather than of things which *are;* and this diſtinction of language was increaſed by the very aim of the writers, which

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which was generally to influence the conduct as well as the opinions of their ſcholars. It was reſerved for modern times to bring this ſtudy into the pure form of philoſophy, by a careful attention to the phenomena of moral ſentiment, and claſſing theſe according to their generality, and aſcertaining their reſpective ranks by an appeal to experiment, that is, to the general conduct of mankind: and thus it happens that in the modern treatiſes on ethics, juriſprudence, &c. there is leſs frequent reference made to the *officia* or duties, or to the conſtituents of the *ſummum bonum*, than among the ancients, and a more accurate deſcription of the human mind, and diſcrimination of its various moral feelings.

27
The origin of logic and other intellectual ſciences.

It was hardly poſſible to proceed far in in theſe diſquiſitions without attending to the powers of the underſtanding. Differences of opinion were ſupported by reaſonings, or attempts to reaſoning. Both ſides could not be in the right, and there muſt be ſome court of appeals. Rules of argumentation behoved to be acquieſced in by both parties; and it could hardly eſcape the notice of ſome curious minds, that there were rules of truth and falſehood as well as of right and wrong. Thus the human *underſtanding* became an object of ſtudy, firſt in ſubſerviency to the demands of the moraliſts, but afterwards for its own ſake; and it gradually grew up into the ſcience of logic. Still further refinement produced the ſcience of metaphyſics, or the philoſophy of univerſals. But all theſe were *in fact* poſterior to the doctrines of morals; and diſquiſitions on beauty, the principles of taſte, the precepts of rhetoric and criticiſm, were the laſt additions to the ſtudy of the phenomena of mind. And now, ſince the world ſeems to have acquieſed in the mode of inveſtigation of general laws by experiment and obſervation, and to agree that this is all the knowledge that we can acquire of any ſubject whatever, it is to be expected that this branch of philoſophical diſcuſſion will attain the ſame degree of improvement (eſtimated by the coincidence of the doctrines with fact and experience) that has been attained by ſome others.

28
The partial practice of natural philoſophy preceded its ſtudy as a ſcience.

The occupations, however, of ordinary life have oftener directed our efforts towards material objects, and engaged our attention on their properties and relations; and as all ſciences have ariſen from arts, and were originally implied in the maxims and precepts of thoſe arts, till ſeparated from them by the curious ſpeculatiſt, the knowledge of the material ſyſtem of nature was poſſeſſed in detached ſcraps by the practitioners in the various arts of life long before the *natural philoſopher* thought of collecting them into a body of ſcientific doctrines. But there have not been wanting in all ages men of curioſity who have been ſtruck by the uniformity of the operations of nature in the material world, and were eager to diſcover their cauſes.

Accordingly, while the moraliſts and metaphyſicians turned their whole attention to the phenomena of mind, and have produced the ſciences of pneumatology, logic, ethics, juriſprudence, and natural theology, theſe obſervers of nature have found ſufficient employment in conſidering the phenomena of the material world.

The bodies of which it conſiſts are evidently connected by means of thoſe properties by which we obſerve that they produce changes in each other's ſituation. This aſſemblage of objects may therefore be juſtly called a ſyſtem. We may call it the MATERIAL SYSTEM. It is frequently termed NATURE; and the terms NATURAL APPEARANCES, NATURAL CAUSES, NATURAL LAWS, have been generally reſtricted to thoſe which take place in the material ſyſtem. This reſtriction, however, is improper, becauſe there is no difference in the manner in which we form our notions of thoſe laws, and reaſon from them, both with reſpect to mind and body. Or if there is to be any reſtriction, and if any part of the ſtudy of the univerſe is to be excluded in the application of theſe terms, it is that part only which conſiders moral obligation, and rather treats of what *ought to be* than of what *is*. As has been already obſerved, there is a conſiderable difference in the language which muſt be employed; but ſtill there is none in the principles of inveſtigation. We have no proof for the extent of any moral law but an appeal to the feelings of the hearts of men, indicated by the general laws or facts which are obſerved in their actions.

29
The nature of the material ſyſtem with the definition of that and other terms.

30
The unreſtricted ſenſe in which ſome of theſe terms are uſed, and its bad conſequences.

But this is only a queſtion of the propriety of language. And no great inconvenience would ariſe from the reſtriction now mentioned if it were ſcrupulouſly adhered to; but unfortunately this is not always the caſe. Some authors uſe the term *natural law* to expreſs *every* coincidence of fact; and this is certainly the proper uſe of the term. The French writers generally uſe the term *loi phyſique* in this enlarged ſenſe. But many authors, miſled by, or taking advantange of, the ambiguity of language, after having eſtabliſhed a law founded on a copious and perhaps unexcepted induction of the phenomena of the material ſyſtem (in which caſe it muſt be conſidered in its reſtricted ſenſe), have, in their explanation of phenomena, extended their principle much farther than the induction on which they had founded the exiſtence of the phyſical law. They have extended it to the phenomena of mind, and have led their followers into great and dangerous miſtakes. Languages, like every other production of human ſkill, are imperfect. They are deficient in terms, and are therefore figurative. The moſt obvious, the moſt frequent, and the moſt intereſting uſes of language, have always produced the appropriated terms, and the progreſs of cultivation has never completely ſupplied new ones. There are certain analogies or reſemblances, or certain aſſociations of ideas, ſo plain, that a term appropriated to one very familiar object will ſerve to ſuggeſt another analogous to it, when aided by the concomitant circumſtances of the diſcourſe; and this with ſufficient preciſion for the ordinary purpoſes of ſocial communication, and without leading us into any conſiderable miſtakes: and it is only the rare and refined diſquiſitions of the curious ſpeculatiſt that bring the poverty and imperfection of language into view, and make us wiſh for words as numerous as our thoughts. There is hardly a ſentence, even of common diſcourſe, in which there are not ſeveral figures either of ſingle words or of phraſes; and when very accurate diſcrimination is required, it is almoſt impoſſible to find words or phraſes to expreſs diſtinctions which we clearly feel. We believe it impoſſible to expreſs, by the ſcanty vocabulary

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cabulary of the Hebrews, the nice diſtinctions of thought which are now familiar to the European philoſopher. In nothing does this imperfection of language appear ſo remarkably as in what relates to mind. Being a late ſubject of ſeparate diſcuſſion, and intereſting only to a few ſpeculatiſts, we have no appropriated vocabulary for it; and all our diſquiſitions concerning its operations are in continual metaphor or figure, depending on very ſlight analogies or reſemblances to the phenomena of the material world. This makes the utmoſt caution neceſſary; and it juſtifies the Britiſh philoſophers, who have been the moſt ſucceſsful in proſecuting the ſtudy of the intellectual ſyſtem, for having, almoſt without exception, reſtricted the terms natural laws, natural cauſes, natural philoſophy, and ſuch like, to the material ſyſtem. With us pneumatology makes no part of phyſics. And we may venture to affirm, that the ſciences have fared better by the reſtriction of the terms. In no country has the ſpirit of liberal diſcuſſion been more encouraged and indulged than in Britain; and her philoſophers have been equally eminent in both branches of ſcience. Their performances in ethics, juriſprudence, and natural theology, are conſidered by all our neighbours as the fountains of knowledge on theſe ſubjects; and Locke and Clarke are names no leſs familiar on the continent than Newton. The licentious and degrading doctrines of the Gallican ſchool have as yet made little impreſſion here; and man is ſtill conſidered among us as a glorious creature, born to, and fitted for, the nobleſt proſpects.

31 The term *phyſics* defined as it is generally underſtood in Britain.

Phyſics, then, is with us the ſtudy of the material ſyſtem, including both natural hiſtory and philoſophy. The term is not indeed very familiar in our language; and in place of *phyſicus* and *diſciplina phyſica*, we more generally uſe the terms *naturaliſt* and *natural knowledge*. The term *natural philoſophy*, in its common acceptation, is of leſs extent. The field of phyſical inveſtigation is ſtill of prodigious extent; and its different quarters require very different treatments, make very different returns, and accordingly have engaged in their particular cultivation perſons of very different talents and taſtes. It is of ſome importance to perceive the diſtinctions, and to ſee how the wants and propenſities of men have led them into the different paths of inveſtigation; for, as has been more than once obſerved, all ſciences have ſprung from the humble arts of life, and both go on improving by means of a cloſe and conſtant correſpondence.

32 The phenomena of the material ſyſtem arranged into two claſſes.

All the phenomena of the material ſyſtem may be arranged into two claſſes, diſtinguiſhed both by their objects and by the proper manner of treating them.

The firſt claſs comprehends all the appearances which are exhibited in the *ſenſible motions* of bodies, and their actions on each other producing *ſenſible motion*.

The ſecond claſs comprehends the appearances which are exhibited in the *inſenſible* motions and actions of the inviſible particles of matter.

33 Examples of thoſe of the firſt claſs,

Of the phenomena of the firſt claſs we have examples in the planetary motions, the motions of heavy bodies, the phenomena of impulſe, the motions and actions of machines, the preſſure and motions of fluids, the ſenſible actions of magnetical and electrical bodies, and the motions of light.

34 and of thoſe of the ſecond.

We have examples of the ſecond claſs in the phenomena of heat and mixture, and thoſe exhibited in the growth of animals and vegetables, and many phenomena of ſolid, fluid, magnetical, electrical, and luminous bodies, in which no change of place can be obſerved.

35 This arrangement is apparently natural.

Thus it appears that there is a diſtinction in the phenomena ſufficiently great to warrant a diviſion of the ſtudy, and to make us expect a more rapid improvement by this diviſion. Nay, the diviſion has been made by nature itſelf, in the acquaintance which men have attained with her operations without ſtudy, before ſcience appeared, and while art conſtituted all our knowledge.

36 Of the progreſs of knowledge in rude ages.

Before man had recourſe to agriculture as the moſt certain means of procuring ſubſiſtence, our acquaintance with external ſubſtances was principally that of the natural hiſtorian; conſiſting of a knowledge of their fitneſs for food, medicine, or accommodation, their places of growth or habitation, and the means of procuring them, depending on their manner of life or exiſtence. It required a ſtudied attention to theſe circumſtances to give riſe to agriculture, which therefore generally made its appearance after men had been in the practice of keeping flocks; by which means they were more at their eaſe, and had ſome leiſure to attend to the objects around them, and in particular to thoſe circumſtances of ſoil and weather which affected the growth of their paſture.

37 The origin of agriculture, phyſic, ſurgery, and chemiſtry.

When agriculture and a rude medicine were thus eſtabliſhed, they were the firſt *arts* which had their foundation in a *ſyſtem of laws*, by which the operations of nature were obſerved to be regulated; and with theſe arts we may begin the *general ſtudy of nature*, which was thus divided into two different branches.

The rude phyſician would be at firſt a collector of *ſpecifics*; but by degrees he would obſerve reſemblances among the *operations* of his drugs, and would claſs them according to theſe reſemblances. He would thus come to attend leſs to the drug than to its mode of operation; and would naturally ſpeculate concerning the connection between the operation and the economy of animal life. His art now becomes a ſcientific ſyſtem, connected by principle and theory, all proceeding on the obſervation of changes produced by one kind of matter on another, but all out of ſight. The frequent recourſe to the vegetable kingdom for medicines would cauſe him to attend much more minutely to the few plants which he has occaſion to ſtudy than the huſbandman can do to the multitude he is obliged to rear. The phyſician muſt learn to think, the huſbandman to work. An analogy between the economy of animal and vegetable life could hardly fail to engage the attention of the phyſician, and would make him a botaniſt, both as a claſſifier of plants and as a philoſopher.

He would naturally expect to unite the ſervices of his drugs by combining them in his recipes, and would be ſurpriſed at his diſappointments. Curious and unexpected changes would frequently occur in his manipulations: the ſenſible qualities, and even the external appearances of his ſimples, would be often changed, and even inverted by their mixture; and their medicinal properties would frequently vaniſh from the compound, and new ones be induced. Theſe are curious, and to him intereſting facts; and he would naturally be inquiſitive af-

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ter the principles which regulate these changes. His skill in this would by degrees extend beyond the immediate use for the knowledge; and the more curious speculatist would lay the foundations of a most extensive and important science, comprehending all the phenomena of heat and mixture.

Along with this, and springing from the same source, another science must arise, contemplating the appearances of animal and vegetable life, and founded on a careful observation and accurate description of the wonderful machine. The most incurious of men have in all ages been affected by the displays of wisdom and contrivance in the bodies of animals, and immediately engaged in investigation into the uses and functions of their various parts and organs. The phenomena have been gradually discriminated and arranged under the various heads of nutrition, concoction, secretion, absorption, assimilation, rejection, growth, life, decay, disease, and death; and, in conformity to the doctrines which have with greater or less evidence been established on these subjects, the action of medicines, and the whole practice of physic and surgery, has been established in the form of a liberal or scientific art.

38
The origin of the knowledge of the mechanical powers.

The husbandman in the mean time must labour the ground which lies before him. He, too, is greatly interested in the knowledge of the vegetable economy, and forms some systems on the subject by which he regulates his labours: but he sees, that whatever is the nature of vegetable life, he must work hard, and he searches about for every thing which can tend to diminish his labour. The properties of the lever, the wedge, and the inclined plane, soon become familiar to him; and without being able to tell on what their efficacy depends, he uses them with a certain sagacity and effect. The strength of timber, the pressure and force of water, are daily seen and employed by him and other artisans who labour for their mutual accommodation; and some rude principles on these subjects are committed to memory. Many tools and simple machines are by this time familiar; and thus the *general* properties of matter, and the general laws of the actions of bodies on each other, become gradually matter of observation and reflection; and the practical mechanic will be frequently improving his tools and machines. The general aim is to produce a greater quantity of work by the same exertion. The attempts to improvement will be aukward, and frequently unsuccessful. When a man finds, that by increasing the length of his lever he increases his power of overcoming a resistance, a small degree of curiosity is sufficient to make him inquire in what proportion his advantage increases. When he finds that a double length gives him a double energy, he will be surprised and mortified to find, that at the end of the day he has not performed twice the quantity of work: but, after much experience, he will learn that every increase of energy, by means of a machine, is nearly compensated by an increase of time in the performance of his task; and thus one of the great and leading principles of practical mechanics was inculcated in a manner not to be forgotten, and the practical mechanic was brought to speculate about motion and force, and by gradual and easy steps the general laws of simple motions were established.

39
The origin of mathematics.

It is evident that these speculations cannot be carried on, nor any considerable knowledge acquired, without some acquaintance with the art of measurement: and the very questions which the mechanic wishes to solve, presuppose some advances in this art, which in process of time refined itself into mathematics, the most perfect of all the sciences. All the phenomena of sensible motion afford employment to the mathematician. It is performed in a double or triple time, through a double or triple space, by a double or triple body, by the exertion of a double or triple force, produces a double or triple effect, is more to the right or to the left, upwards or downwards, &c. In short, every affection of motion is an object of mathematical discussion. Such a science must have appeared ere now in the form of an art, in consequence of the mutual transactions of men. These among an uncultivated people are chiefly in the way of barter. If I want corn from a peasant, and have nothing to give for it but the cloth which I have made, we must fall on some way of adjusting our terms in respect of the quantity. We should soon discover that the length, and breadth, and depth, of the box or bag, were equally important; and it was not difficult to see, that if any of them were doubled or tripled, the quantity of grain would be so too; if two of them were doubled, the grain would be quadrupled; and if all the three were doubled the quantity of grain would be increased eight times: the same thing would be observed with respect to my cloth. By such transactions as these, a few of the properties of plane and solid numbers and figures would become known, and the operations of multiplication and division, where arithmetic is combined with geometry: and daily observation shows us, that the more abstruse properties of number and figure, which to the generality of mankind are so insignificant, lay hold on the fancy of some individuals with such force, as to abstract them from every other intellectual entertainment, and are studied with a keenness and perseverance almost unequalled in any other walk of science. To most men the performance of a machine is a more attractive object than the properties of a figure, and the property of a figure more entertaining than that of a number; but the fact seems to have been otherwise. Before Pythagoras had invented the theorem that bears his name (see PHILOSOPHY, N° 15. and note H), and which is among the first elements of geometry, he had reformed the Grecian music by the addition of a note to their scale, and this addition proceeds on a very refined speculation on the properties of numbers; so that among the Greeks arithmetic must have made considerable progress, while geometry was yet in its cradle: and we know to what astonishing length they prosecuted the science of pure geometry, while their knowledge of mechanical principles was almost nothing. Also the Arabs hardly made any addition to the geometry of the Greeks, if they did not rather almost completely forget it; whilst they improved their arithmetic into algebra, the most refined and abstracted branch of human knowledge. There is such a distance, in point of simplicity, between pure mathematics and the most elementary mechanics, that the former continued to make rapid steps to improvement in more modern times, while the latter languished in its infancy, and hardly deserved the name of science till very lately, when the great demand for it, by the increase and improvement in manufactures, both interested many in the study, and facilitated its progress, by the multitude of machines which were contriving on all hands by the manufacturers and artisans: and even at present it must be

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be acknowledged, that it is to them that we are indebted for almoſt every new invention in mechanics, and that the ſpeculatiſt ſeldom has done more than improve the invention, by exhibiting its principles, and thus enabling the artiſt to correct its imperfections; and now ſcience and art go hand in hand, mutually giving and receiving aſſiſtance. The demands of the navigator for mathematical and aſtronomical knowledge have dignified theſe ſciences; and they are no longer the means of elegant amuſement alone, but merit the munificence of princes, who have erected obſervatories, and furniſhed voyages of diſcovery, where the mathematical ſciences are at the ſame time cheriſhed and applied to the moſt important purpoſes.

This ſhort ſketch of what may be called *the natural hiſtory of phyſical ſciences* will not, we hope, be thought improper or unprofitable. It tends to confirm an aſſertion often alluded to, that the proſecution of the ſtudy of nature will be more ſucceſsful, if we imitate her mode of proceeding, and divide the labour. It will be ſtill further confirmed by attending to the ſcientific difference of the phenomena, which marks out a different mode of proceeding, and a difference in the knowledge which we ſhall ultimately acquire, after our moſt ſucceſsful reſearches.

40 The connecting principle of concomitant events is totally unknown.

In both claſſes of phenomena already diſtinguiſhed (N° 6.) we muſt grant, that the principle which connects the pairs of concomitant events, rendering the one the inſeparable companion of the other, is totally unknown to us, becauſe it is not the immediate object of our perception.

41 In the firſt claſs, however, the exertion of this principle may be accurately obſerved,

But in the phenomena of the firſt claſs, we ſee the *immediate* exertion of this principle, whatever it may be; we can obſerve the exertion with accuracy; we can determine its kind and degree, which are the ſigns and meaſures of the kind and degree of the unperceived cauſe. This exertion, being always ſome modification of motion, allows us to call in the aid of mathematical knowledge, and thus to aſcertain with the preciſion peculiar to that ſcience the energy of the cauſe, judging of the tendency and quantity by the tendency and the quantity of the obſerved effect.

42 but not in the ſecond:

But in the ſecond claſs of phenomena the caſe is very different. In the operations of chemiſtry, for inſtance, the *immediate* exertion of the cauſe is not perceived: all that we obſerve is the aſſemblage of particles which obtains before mixture, and that which takes place when it is completed, and which we conſider as its reſult. The procedure of nature in producing the change is unſeen and unknown. The ſteps are hid from our obſervation. We are not only ignorant of the cauſe which determines one particle of our food to become a part of our body while others are rejected, but we do not ſee the operation. We are not only ignorant of the cauſe which determines a particle of vitriolic acid to quit the foſſil alkali with which it is united in Glauber ſalt, and to attach itſelf to a particle of magneſia already united with the muriatic acid, which alſo quits it to unite with the alkali, but we do not ſee the operation. The particles and their motions are not the objects of our ſenſes; and all that we ſee is the Epſom ſalt and common ſalt ſeparated from the water in which we had formerly diſſolved the ſal mirabile and the muriated magneſia. The motions, which are the *immediate* effects of the changing cauſes, and therefore their *only indications, characteriſtics, and meaſures*, fitted to ſhow their nature, are hid from our view.

Our knowledge therefore of theſe phenomena muſt be leſs perfect than that of the phenomena of the former claſs; and we muſt here content ourſelves with the diſcovery of more remote relations and remote cauſes, and with our ignorance of the very powers of nature by which theſe changes are brought about, and which are cognoſcible only by their immediate effects, viz. the motions which they produce unſeen. The knowledge which we do really acquire is ſomewhat ſimilar to what the mechanical philoſopher has acquired when he has diſcovered, by many experiments and inveſtigations, that magnets attract each other by their diſſimilar poles, and repel each other by their ſimilar poles, and do not act at all on any bodies but loadſtones and iron. Here we leave undiſcovered all that is moſt curious in the phenomenon, viz. how theſe attractions and repulſions are produced; and even here the magnetical philoſopher has the advantage of ſeeing the agents and the operation. 43 And therefore the phenomena of the ſecond claſs are leſs underſtood.

But philoſophers attending to this circumſtance, that, even in theſe caſes, the changes are produced by motions, or conſiſt in motions, however unperceived theſe may be, have concluded, that the laws according to which nature operates in producing theſe changes are ſimilar to the laws which regulate her operations in the ſenſible actions of bodies, or are included in them; and that the motions, though unſeen, and the moving forces, are perfectly ſimilar. They have therefore employed ſimilar modes of inveſtigation, applying the laws of impulſe, and calling in the aid of mathematical knowledge. 44 Though ſome philoſophers have attempted to explain them by the doctrine of motion;

Of this we have many examples in the writings of Dr Freind, Keil, Bernouilli, Helſham, Boerhaave, Hartley, and others, who have delivered theories of fermentation, ſolution, precipitation, cryſtallization, nutrition, ſecretion, muſcular action, nay even of ſenſation and intelligence, founded, as they think, on the laws of motion, and illuſtrated and ſupported by mathematical reaſoning. Lord Bacon himſelf, that careful and ſagacious diſtinguiſher of intellectual operations, has gone into the ſame track in his explanation of the phenomena of fire and combuſtion: and Sir Iſaac Newton has made ſeveral attempts of the ſame kind, although with peculiarities which always characteriſe his diſcuſſions, and make them very different from thoſe of an inferior claſs.

But the ſucceſs of theſe philoſophers has hitherto been very diſcouraging: indeed they had no title to expect any; for their whole trains of reaſoning have proceeded on analogies which were not obſerved, but aſſumed or *ſuppoſed* without any authority. There is not that ſimilarity in the phenomenon, or in the viſible effect, which is abſolutely neceſſary for a ſucceſsful reaſoning by analogy. We do not obſerve any local motion, any change of place, which alone enables us to reaſon mathematically on the ſubject. And to make the caſe deſperate, this ill-founded analogy has been mixed with hypotheſes completely gratuitous. Certain forms have been aſſigned to the particles, and certain modes of action have been laid down for them, for whoſe reality we have not the leaſt argument or indication: and to complete the matter, theſe fancied forms and laws of action have been ſuch as are either ſelf-contradictory and inconſiſtent, or they 45 but their attempts have been unſucceſsful.

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they have been such as, if allowed to act in a way analogous to what we observe in the sensible motions of bodies, would produce effects totally different from those which are observed. These atomical theories, as they are called, transgress every rule of philosophical discussion, and even the best of them are little better than trifling amusements. By far the greatest part of them only serve to raise a smile of pity and contempt in every person at all acquainted with mechanical philosophy. Whenever we see an author attempting to explain these hidden operations of nature by invisible fluids, by æthers, by collisions, and vibrations, and particularly if we see him in roducing mathematical reasonings into such explanations—the best thing we can do is to shut the book, and take to some other subject. That we may not be thought to speak presumptuously on this occasion, we only beg leave to remind our readers, that the united knowledge of the most eminent mathematicians of Europe has not yet been able to give any thing more than an approximation to the solution of the problem of three bodies; that is, to determine with accuracy the motions of three particles of matter acting on each other in the simplest of all possible manners, viz. by forces varying as the squares of the distances inversely: and the vibrations of elastic bodies, of any but the very simplest possible forms, are to this day beyond the reach of investigation. What then should be our expectations in cases where millions of particles are acting at once, of forms unobserved, and with forces unknown, and where the object is not a determination of an average result of many, where the precise state of an individual particle need not be known, but where it is this very precise state of each single particle that we want to know? What can it be but uncertainty and mistake?

46 The advantage derived in these speculations from mathematical philosophy.

Notwithstanding these discouraging circumstances, we must observe that this kind of inquiry has greatly improved of late years, along with the improvement and extension of mathematical philosophy, and since philosophers have given over their incessant attempts to explain every thing by impulse; and we need not despair of making still farther advances, if we will content ourselves with going no farther than Newton has done in his explanation of the planetary motions. He has immortalized his own name, and has added immensely to our stock of useful knowledge: yet he has stopped short at the discovery of the fact of universal gravitation; and all who have endeavoured to explain or account for this fact have only exposed themselves to pity. We may perhaps be one day able to demonstrate from the phenomena that the particles of matter have certain mutual tendencies to or from each other, exerted according to fixed or invaried rules; and from these tendencies we may be able to explain many other phenomena, and predict the consequences, with as much certainty and evidence as an astronomer calculates a future eclipse. This would be a great acquisition, and perhaps more is impossible: and the road to this has been hinted by Sir Isaac Newton, who has expressed his suspicion, that as the great movements of the solar system are regulated by universal gravitation, so the mutual actions of the particles of matter are produced and regulated by tendencies of a similar kind, *equally* but not *more* inexplicable, and of which the laws of action are to be discovered by as careful an attention to the phenomena, and by the same patient thinking, which he has employed on the planetary motions. And a beautiful introduction to this new and almost unbounded field of inquiry has been given us by the celebrated Abbé Boscovich, in his Theory of Natural Philosophy, where he has shown how such mutual tendencies, similar in every ultimate particle of matter, and modified by conditions that are highly probable, nay almost demonstrable, will not only produce the sensible forms of solidity, hardness, elasticity, ductility, fluidity, and vapour, under an inconceivable variety of subordinate appearances, and the observed laws of sensible motion, but will go far to explain the phenomena of fusion, congelation, solution, crystallization, &c. &c. &c. both in chemistry and physiology. We earnestly recommend this work to the perusal of all who wish to obtain a distinct notion of the internal constitution of natural bodies, and of the way in which the uniting forces produce their ultimate and sensible effects. Any person, possessed of a moderate share of mathematical knowledge, will be convinced that the process of nature is not very different from what he describes; and that much of what we observe must happen as he says, even although the ultimate atoms of matter are not inextended mathematical points, accompanied with attracting and repelling forces.

47 Our ignorance still great, and the probable increase of knowledge among posterity.

But we have many steps to make before we begin this study: Nature opens to us an immense volume; and we doubt not that our posterity will long find employment in the perusal, even though advancing with the eagerness and success of the last century. We have not yet arrived at the threshold in many parts of this research: In many parts of chemistry, for instance, we are as yet uncertain with respect to the phenomena themselves, which are to be the subjects of this discussion. The composition of bodies must be fully understood before we begin to speak of the forces which unite their particles, or speculate about their modes of action. As long as water was considered as an element, we were ignorant of the forces inherent in its particles; we are perhaps still ignorant of this; but we now know that they are extremely different from what we formerly supposed them to be. It is but in a very few, if in any, cases of chemical combination, that we even know what are the ingredients: till we know this, it is too soon to speculate about their mode of union. Our ignorance in the real events in the animal and vegetable economy is still greater. Our first task therefore is to proceed, as we are now doing, in the accurate examination and classification of the phenomena themselves; and, without attempting to bring them within the pale of mathematical philosophy, by attempting what are called mechanical explanations, let us give up the consideration of these hidden operations, and augment to the utmost our list of secondary laws of visible but remote connections. All the mechanical speculations of the honourable Robert Boyle about the sensible qualities of things are now forgotten; but his chemical experiments preserve all their value, and are frequently referred to. The same may be said of the sagacious Dr Hales, whose fanciful notions of internal conflicts, and collisions, and vibrations, derogate nothing from the value of the curious facts which he has established both in the animal and vegetable economy.

48 The particular divisions of physical science in Britain.

This distinction in the nature of the phenomena, and this difference in the nature of the knowledge which is to be acquired, and the means which are to be employed

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ployed for the ſucceſsful proſecution of theſe two branches of general phyſics, has occaſioned a ſtill farther reſtriction (at leaſt in Britain) of the term NATURAL PHILOSOPHY. It is particularly applied to the ſtudy of the phenomena of the firſt claſs, while thoſe of the ſecond have produced the ſciences of CHEMISTRY and PHYSIOLOGY.

Natural philoſophy and chemiſtry have generally been made particular inſtitutions in our ſeminaries of learning, but phyſiology has more commonly been taught in conjunction with anatomy, medicine, and botany.

The phenomena of the firſt claſs have been uſually called MECHANICAL, in order to diſtinguiſh them from thoſe obſerved in the operations of chemiſtry, and in the animal and vegetable economy; and the explanations which have been attempted of ſome of the laſt, by applying the laws obſerved in the phenomena of the firſt claſs, have been called *mechanical explanations*.

As this firſt claſs is evidently but a part of general phyſics, there is ſome impropriety in giving the name *natural philoſophy* to a courſe of doctrines which is confined to theſe alone. Indeed at the firſt inſtitution of univerſities, the lectures given in the *Schola Phyſica* were much more extenſive, comprehending almoſt all the phenomena of the material world: but as all arts and ſciences have improved moſt where the labour has been moſt divided, it was found more conducive to the advancement of knowledge that ſeparate inſtitutions ſhould be founded for the ſtudies of natural hiſtory, chemiſtry, phyſiology, &c.; and thus the phenomena, purely mechanical, and a few others in magnetiſm, electricity, and optics, which either were ſuſceptible of mathematical treatment, or had little connection with the ſtudies of chemiſtry and phyſiology, were left to the care of the profeſſor of natural philoſophy.

As the terms *chemiſtry* and *phyſiology* have been applied to two very important branches of general phyſics, we think that a more ſpecific or characteriſtic name might be appropriated to the other, and that it might very properly be termed MECHANICAL PHILOSOPHY.

It only remains to make a few obſervations on the diſtinctive means of proſecuting theſe ſtudies with ſucceſs, and to point out ſome of the advantages which may reaſonably be expected from a careful proſecution of them: and as the ſecond branch has been fully treated under the ſeveral articles of CHEMISTRY, PHYSIOLOGY, &c. we ſhall confine ourſelves to what is uſually called NATURAL PHILOSOPHY.

49
Mechanical philoſophy defined, and its principles explained.

MECHANICAL PHILOSOPHY may, in conformity with the foregoing obſervations, be defined, "the ſtudy of the ſenſible motions of the bodies of the univerſe, and of their actions producing ſenſible motions, with the view to diſcover their cauſes, to explain ſubordinate phenomena, and to improve art."

The principle upon which all philoſophical diſcuſſion proceeds is, that *every change which we obſerve in the condition of things is conſidered by us as an effect, indicating the agency, characteriſing the kind, and meaſuring the degree, of its cauſe.*

In the language of mechanical philoſophy, the cauſe of any change of motion is called a moving or changing FORCE.

Mechanical Philoſophy.

The diſquiſitions of natural philoſophy muſt therefore begin with the conſideration of motion, carefully noticing every affection or quality of it, ſo as to eſtabliſh marks and meaſures of every change of which it is ſuſceptible; for theſe are the only marks and meaſures of the changing forces. This being done, it only remains to apply them to the motions which we obſerve in the univerſe.

50
The laws of motion and their application.

From the general principle of philoſophical diſcuſſion already mentioned, there flow directly two axioms.

1. *Every body perſeveres in a ſtate of reſt, or of uniform rectilineal motion, unleſs affected by ſome moving force.*

2. *Every change of motion is in the direction and in the degree of the force impreſſed.*

Theſe are uſually called the LAWS OF MOTION. They are more properly laws of human judgment, with reſpect to motion. Perhaps they are neceſſary truths, unleſs it be alleged that the general principle, of which they are neceſſary conſequences, is itſelf a contingent though univerſal truth.

By theſe two axioms, applied *in abſtracto* to every variety of motion, we eſtabliſh a ſyſtem of general doctrines concerning motions, according as they are ſimple or compounded, accelerated, retarded, rectilineal, curvilineal, in ſingle bodies, or in ſyſtems of connected bodies; and we obtain correſponding characteriſtics and meaſures of accelerating or retarding forces, centripetal or centrifugal, ſimple or compound.

We have an illuſtrious example of this abſtract ſyſtem of motion and moving forces in the firſt book of Sir Iſaac Newton's Mathematical Principles of Natural Philoſophy. Euler's *Mechanica ſive Scientia Motus*, Herman's *Phoronomia ſive de Viribus Corporum*, and D'Alembert's *Traité de Dynamique*, are alſo excellent works of the ſame kind. In this abſtract ſyſtem no regard is paid to the caſual differences of moving forces, or the ſources from which they ariſe. It is enough to characteriſe a double accelerating force, for inſtance, that it produces a double acceleration. It may be a weight, a ſtream of water, the preſſure of a man; and the force, of which it is ſaid to be double, may be the attraction of a magnet, a current of air, or the action of a ſpring.

Having eſtabliſhed theſe general doctrines, the philoſopher now applies them to the *general* phenomena of the univerſe, in order to diſcover the nature of the forces which really exiſt, and the laws by which their operations are regulated, and to explain intereſting but ſubordinate phenomena. This is the chief buſineſs of the mechanical philoſopher; and it may with ſome propriety be called *the mechanical hiſtory of nature*.

51
Of the arrangement of the mechanical phenomena of the univerſe.

Some method muſt be followed in this hiſtory of mechanical nature. The phenomena muſt be claſſed by means of their reſemblances, which infer a reſemblance in their cauſes, and theſe claſſes muſt be arranged according to ſome principle. We have ſeen no method which appears to us leſs exceptionable than the following.

52
The generality of the phenomena is the principle of arrangement.

The principle of arrangement is the generality of the phenomena; and the propriety of adopting this principle, ariſes from the probability which it gives us of more readily diſcovering the moſt general actuating forces, whoſe agency is implicated in all other phenomena of leſs

leſs extent; and therefore ſhould be previouſly diſcuſſed, that we may detect the diſcriminating circumſtances which ſerve to characteriſe the ſubordinate phenomena, and are thus the marks of the diſtinguiſhing and inferior natural powers.

53 The laws of motion are firſt applied to aſtronomical phenomena.

The moſt general of all phenomena is the curvilineal motion of bodies in free ſpace; it is obſerved through the whole extent of the ſolar ſyſtem.

The mechanical hiſtory of nature begins therefore with aſtronomy. Here, from the general phenomena of the planetary motions, is evinced the *fact* of the mutual deflection of every body towards every other body, and this in the inverſe proportion of the ſquares of the diſtance, and the direct proportion of the quantity of matter. This is the fact of UNIVERSAL GRAVITATION, indicating the agency, and meaſuring the intenſity, of the univerſal force of mutual gravity.

Having eſtabliſhed this as an univerſal fact, the natural philoſopher proceeds to point out all the particular facts which are comprehended under it, and whoſe peculiarities characteriſe the different movements of the ſolar ſyſtem. That is, in the language of philoſophy, he gives a theory or explanation of the ſubordinate phenomena; the elliptical motions of the planets and comets, their mutual diſturbances; the lunar irregularities; the oblate figure of the planets; the nutation of the earth's axis; the preceſſion of the equinoxes; and the phenomena of the tides and trade winds: and he concludes with the theory of the parabolic motion of bodies projected on the ſurface of this globe, and the motion of pendulums.

54 The application of this ſcience to the arts of life.

As he goes along, he takes notice of the applications which may be made to the arts of life of the various doctrines which are ſucceſſively eſtabliſhed; ſuch as chronology, aſtronomical calculation, dialling, navigation, gunnery, and the meaſuring of time.

55 The nature of gravitation,

If a ſquare parcel of ſand be lying on the table, and the finger be applied to any part of it to puſh it along the table, that part is removed where you will, but the reſt remains in its place; but if it is a piece of ſand-ſtone of the ſame materials and ſhape, and the finger is applied as before, the whole is moved; the other parts accompany the part impelled by the finger in all its motions.

56 and of coheſion.

From the moon's accompanying the earth in all its motions round the ſun, we infer a moving force which connects the moon and earth. In like manner, we muſt conclude that a moving force connects the particles of the ſtone; for we give the name *force* to every thing which produces motion: We call it the force of COHESION; a term which, like gravitation, expreſſes merely a fact.

This ſeems to be the next phenomenon of the univerſe in point of extent.

57 Mode of inveſtigating the laws of coheſion.

Having, from the general phenomenon, eſtabliſhed the exiſtence of this force, the philoſopher proceeds to aſcertain the laws by which its exertions are regulated; which is the aſcertaining its diſtinctive nature and properties. This he does in the ſame way that he aſcertained the nature of planetary gravitation, *viz.* by obſerving more particularly the various phenomena.

Here is opened a moſt extenſive and varied field of obſervation, in which it muſt be acknowledged that very little regular and marked progreſs has been made. The variety in the phenomena, and the conſequent variety in the nature of the connecting forces, appear as yet inconceivably great; and there ſeems little probability of our being able to detect in them all any ſameneſs, combined with the other diſtinguiſhing circumſtances, as we have done in the caſe of gravity. Yet we ſhould not deſpair. Boſcovich has ſhown, in the moſt unexceptionable manner, that although we ſhall ſuppoſe that every atom of matter is endued with a perfectly ſimilar force, acting in a certain determined ratio of the ſmall and imperceptible diſtances at which the particles of matter are arranged with reſpect to each other, the external or ſenſible appearances may, and muſt, have all that variety which we obſerve. He alſo ſhows very diſtinctly how, from the operation of this force, muſt ariſe ſome of the moſt general and important phenomena which characteriſe the different forms of tangible bodies.

We obſerve the chief varieties of the action of this CORPUSCULAR force on the bodies which we denominate *hard*, *ſoft*, *ſolid*, *fluid*, *vaporous*, *brittle*, *ductile*, *elaſtic*. We ſee inſtances where the parts of bodies avoid each other, and require external force to keep them together, or at certain ſmall diſtances from each other. This is familiar in air, vapours, and all compreſſible and elaſtic bodies.

This is evidently a moſt curious and intereſting ſubject of inveſtigation. On the nature and action of theſe corpuſcular forces depends the ſtrength or firmneſs of ſolids, their elaſticity, their power of communicating motion, the preſſure, and motion, and impulſe of fluids; nay, on the ſame actions depend all the chemical and phyſiological phenomena of expanſion, fuſion, congelation, vaporiſation, condenſation, ſolution, precipitation, abſorption, ſecretion, fermentation, and animal and vegetable concoction and aſſimilation.

Out of this immenſe ſtore of phenomena, this inexhauſtible fund of employment for our powers of inveſtigation, the natural philoſopher ſelects thoſe which lead directly to the production or modification of ſenſible motion.

He will therefore conſider,

58 The production of motion by impulſe has been thought the moſt familiar fact in nature.

1. The communication of motion among detached and free bodies, eſtabliſhing the laws of impulſe or colliſion. This has always been conſidered as the elementary doctrine of mechanical philoſophy, and as the moſt familiar fact obſerved in the material world; and in all ages philoſophers have been anxious to reduce all actions of bodies on each other to impulſe, and have never thought a phenomenon completely explained or accounted for till it has been ſhown to be a caſe of impulſe. This it is which has given riſe to the hypotheſes of vortices, ethers, magnetic and electric fluids, animal ſpirits, and a multitude of fancied intermediums between the ſenſible maſſes of matter, which are ſaid in common language to act on each other. A heavy body is ſuppoſed to fall, becauſe it is impelled by a ſtream of an inviſible fluid moving according to certain conditions ſuited to the caſe. The filings of iron are ſuppoſed to be arranged round a magnet, by means of a ſtream of magnetic fluid iſſuing from one pole, circulating perpetually round the magnet, and entering at the other pole, in the ſame manner as we obſerve the flote-graſs arranged by the current of a brook.

59 But this opinion is very queſtionable.

But the philoſopher who has begun the mechanical ſtudy of nature by the abſtract doctrines of dynamics, and made its firſt application to the celeſtial phenomena, and who has attended carefully to the many analogies

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logies between the phenomena of gravitation and cohesion, will be at least ready to entertain very different notions of this matter. He will be so far from thinking that the production of motion by impulse is the most familiar fact in nature, that he will acknowledge it to be comparatively very rare; nay, there are some appearances in the facts, which are usually considered as instances of impulsion, which will lead him to doubt, and almost to deny, that there has *ever been observed* au instance of one body putting another in motion by coming into absolute contact with it, and striking it; and he will be disposed to think that the production of motion in this case is precisely similar to what we observe when we gently push one floating magnet towards another, with their similar poles fronting each other. There will be the same production of motion in the one and diminution of it in the other, and the same uniform motion of the common centre of gravity: and, in this case of the magnets, he sees completely the necessity of a law of motion, which is not an axiom, but is observed through the whole of nature, and which receives no explanation from any hypothesis of an intervening fluid, but is even totally inconsistent with them. We mean, "that every action of one body on another is accompanied by an equal and opposite action of that other on the first." This is usually called the *equality of action and reaction*: it is not intuitive, but it is universal; and it is a necessary consequence of the perfect similarity of the corpuscular forces of the same kinds of matter. This general fact, unaccountable on the hypothesis of impelling fluids, is considered in the planetary motions as the unequivocal indication of the sameness of that gravity which regulates them all. The rules of good reasoning should make us draw the same conclusion here, that the particles of tangible matter are connected by equal and mutual forces, which are the *immediate causes* of all their sensible actions, and that these forces, like gravitation, vary with every change of distance and situation.

60 Motion seems to be produced from the equality of action and reaction.

The laws of collision and impulsion being now established, either as original facts or as consequences of the agency of equal and mutual forces which connect the particles of matter, the philosopher considers,

61 Of motion as it respects the theory of machines, &c.

2. The production of motion by the intervention of solid bodies, where, by reason of the cohesion of matter, some of the motions are necessarily confined to certain determinate paths or directions. This is the case in all motions round fixed points or axes, or along planes or curves which are oblique to the action of the forces.

62 MECHANICS.

This part of the study contains the theory of machines, pointing out the principles on which their energy depends, and consequently furnishing maxims for their construction and improvement. But these observations do not complete the discussion of the mechanism of solid bodies: they are not only solid and inert, but they are also heavy; therefore the action of gravity must be combined with the consequences of solidity. This will lead to discussions about the centre of gravity, the theory and construction of arches and roofs, the principles of stability and equilibrium, the attitudes of animals, and many particulars of this kind.

63 The nature and definition of fluidity.

3. The philosopher will now turn his attention to another form, in which tangible matter exhibits many interesting phenomena, *viz.* FLUIDITY. The first thing to be attended to here is, *What is that particular form of existence?* What is the precise phenomenon which characterises fluidity? What is the definition of a fluid? This is by no means an easy question, and considerable objections may be stated against any definition that has been given of it. Sir Isaac Newton says, that *a fluid is a body whose particles yield to the smallest impression, and by so yielding are easily moved among themselves.* It may be doubted whether this be sufficiently precise; what is meant by the *smallest impression?* and what is *easily* moving? Is there any precise degree of impression to which they do not yield; and do they oppose any resistance to motion? And a stronger objection may be made: It is not clear that a body so constituted will exhibit all the appearances which a body acknowledged to be fluid does really exhibit. Euler offers some very plausible reasons for doubting whether it will account for the horizontal surface, and the complete propagation of pressure through the fluid in every direction; and therefore prefers selecting *this last phenomenon*, the propagation of pressure *quâqua-versum*, as the characteristic of fluidity, because a body having this constitution (on whatever circumstances it may depend) will have every other observed property of a fluid. But this definition is hardly simple or perspicuous enough; and we think that the objections against Newton's more simple and intelligible definition are not unanswerable. Boscovich defines a fluid to be, *a body whose particles exert the same mutual forces in all directions*; and shows, that such particles must be indifferent, as to any position, with respect to each other. If no external force act on them, they will remain in every position, and will have no tendency to arrange themselves in one position rather than another; differing in this respect from the particles of solid, or soft, or viscid bodies; which require some force to change their respective positions, and which recover these positions again when but gently disturbed. He illustrates this distinction very beautifully, by comparing a parcel of balls thrown on quicksilver, and attracting each other, with a parcel of magnets in the same situation. The balls will stick together, but *in any position*; whereas the magnets will always affect a particular arrangement.

64 Of the pressure and equilibrium of fluids, or hydrostatics.

When the characteristic phenomenon of fluidity has been selected, the philosopher proceeds to combine this property with gravity, and establishes the doctrines of HYDROSTATICS, or of the pressure and equilibrium of heavy fluids, the propagation of this pressure in every direction; and demonstrates the horizontality of surface assumed by all perfect fluids.

These doctrines and principles enable us to determine several very interesting circumstances respecting the mutual pressure of solids and fluids on each other; the pressures exerted on the bottoms and sides of vessels; the support and whole mechanism of floating bodies, &c.

65 Of the motion of fluids, or hydraulics.

He then considers how fluids will move when their equilibrium of pressure is destroyed; and establishes the doctrines of HYDRAULICS, containing all the modifications of this motion, arising from the form of the vessels, or from the intensity or direction of the pressure which occasions it. And this subject is completed by the consideration of the resistance which fluids oppose to the motion of solid bodies through them, and their impulse on bodies opposed to their action.

These are very important matters, being the foundations of many mechanical arts, and furnishing us with some of our most convenient and efficacious powers for impel-

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impelling machines. They are also of very difficult discussion, and are by no means completely investigated or established. Much remains yet to be done both for perfecting the theories and for improving the arts which depend on them.

66 The importance and difficulty of these branches of science.

It is evident, that on these doctrines depend the knowledge of the motions of rivers and of waves; the buoyancy, equilibrium, and stability of ships; the motion of ships through the waters; the action of the winds on the sails; and the whole arts of marine construction and seamanship.

67 The nature and definition of vapour.

There is another general form of tangible matter which exhibits very different phenomena, which are also extremely interesting; we mean that of VAPOUR. A vapour is a fluid; and all the vapours that we know are heavy fluids: they are therefore subject to all the laws of pressure and impulse, which have been considered under the articles HYDRODYNAMICS. But they are susceptible of great compression by the action of external forces, and expand again when these forces are removed. In consequence of this compression and expansion, the general phenomena of fluidity receive great and important modifications; and this class of fluids requires a particular consideration. As air is a familiar instance, this branch of mechanical philosophy has been called PNEUMATICS.

68 The doctrine of air, or pneumatics.

Under this head we consider the pressure of the atmosphere, and its effects, both on solid and fluid bodies. It produces the rise of waters or other fluids in pumps and syphons, and gives us the theory of their construction: it explains many curious phenomena of nature, such as the motions in the atmosphere, and their connection with the pressure of the air, and its effect on the barometer or weather-glass. Air, when in motion, is called *wind;* and it may be employed to impel bodies. The theory of its action, and of its resistance to moving bodies, are therefore to be considered in this place.

But besides their motions of progression, &c. such as we observe in winds, compressible or elastic fluids are susceptible of what may be termed *internal motion;* a kind of undulation, where the contiguous parts are thrown into tremulous vibrations, in which they are alternately condensed and rarefied; and these undulations are propagated along the mass of elastic fluid, much in the same way in which we observe waves to spread on the surface of water. What makes this an interesting subject of consideration is, that these undulations are the more ordinary causes of sound. A trembling chord, or spring, or bell, agitates the air adjoining to it: these agitations are propagated along the air, and by its intervention agitate the organ of hearing. The mechanism of these undulations has been much studied, and furnishes a very beautiful theory of musical harmony.

69 Of the compressibility of elastic fluids, and its consequences.

The philosopher examines the *law of compressibility* of air and other elastic fluids; and thus gets the knowledge of the constitution of the atmosphere, and of the action of those fluids when employed to impel solid bodies. Gunpowder contains an immense quantity of permanently elastic air, which may be set at liberty by inflammation. When this is done at the bottom of a piece of ordnance, it will impel a ball along the barrel, and discharge it from the muzzle, in the same way that an arrow is impelled by a bow. And thus having discovered in what degree this air presses in proportion to its expansion, we discover its action on the ball through the whole length of the piece, and the velocity which it will finally communicate to it. Here then is contained a theory of artillery and of mines.

70 Of the conversion of bodies into elastic fluids by fire.

Chemistry teaches us, that most bodies can be converted by fire into elastic fluids, which can be employed to act on other bodies in the way of pressure or impulse. Thus they come under the review of the mechanical philosopher; and they have become interesting by being employed as moving forces in some very powerful machines.

These discussions will nearly exhaust all the general mechanical phenomena. There remain some which are much more limited, but furnish very curious and important subjects of investigation.

71 Of the phenomena of loadstone, or magnetism.

The phenomena exhibited between loadstones or magnets and iron have long attracted attention; and the use to which the polarity of the loadstone has been applied, namely, the directing the course of a ship through the pathless ocean, has rendered these phenomena extremely interesting. They are specified by the term MAGNETISM. Considerable progress has been made in the arrangement and generalization of them; but we have by no means been able hitherto to bring them all under one simple fact. The attention has been too much turned to the discovery of the ultimate cause of magnetism; whereas we should have rather employed our ingenuity in discovering all the general laws, in the same manner as Kepler and Newton did with respect to the celestial phenomena, without troubling themselves with the cause of gravitation. Dr Gilbert of Colchester was the first who considered the magnetical phenomena in the truly philosophical manner; and his treatise *De Magnete* may be considered as the first and one of the most perfect specimens of the Baconian or inductive logic. It is indeed an excellent performance; and when we consider its date, 1580, it is a wonder. Æpinus's *Tentamen Theoriæ Magnetismi* is a most valuable work, and contains all the knowledge which we have as yet of the subject.

72 Of electrical phenomena.

There is another class of mechanical phenomena which have a considerable affinity with the magnetical; we mean the phenomena called ELECTRICAL. Certain bodies, when rubbed or otherwise treated, attract and repel other bodies, and occasion a great variety of sensible motions in the neighbouring bodies. Philosophers have paid much attention to these appearances of late years, and established many general laws concerning them. But we have not been more successful in bringing them all under one fact, and thus establishing a complete theory of them, than in the case of magnetism. Franklin and Æpinus are the authors who have been most successful in this respect. Dr Franklin in particular has acquired great celebrity by his most sagacious comparison of the phenomena; which has enabled him to establish a few general laws, almost as precise as those of Kepler, and of equally extensive influence. His discovery too of the identity of thunder and electricity has given an importance and dignity to the whole subject.

73 These are not all mechanical.

There are many phenomena of electricity which cannot be called mechanical, and are of the most curious and interesting kind. As these have little connection with any of the other great branches of physical science, they have generally been considered in treatises of natural philosophy; and along with inquiries into the original cause of electricity in general, continue to engage much of our attention.

The appearances which are presented to us by our sense

Of the phenomena of vision.

sense of seeing form another class, which have always been considered as making a branch of natural philosophy in all seminaries of learning. It does not, however, obviously appear, that they are mechanical phenomena. The intimate nature of light is still a secret. Fortunately it is not necessary to be known to give us a very perfect theory of the chief phenomena. The general laws of optics are so few, so simple, and so precise, that our theories are perhaps more perfect here than in any other branch of physics; but these theories are as yet far removed from the rank of primary facts. Many unknown events happen before the phenomenon comes under the hands of the ordinary optician, so as to become the subjects of the simple laws of reflection and refraction.

75
It has been doubted whether light is corporeal.

It may even be doubted, and has been doubted, whether the phenomena of optics are cases of body in motion; whether all the lines which the optician draws are any thing but the directions along which certain *qualities* are exerted. The side of a ball which is next the candle may be bright and the other side dark, just as the side of a ball which is next the electrical globe is *minus* and the other side *plus*; and all this without any intervening medium. Apparition or visibility may be a quality of a body, depending on the proximity and position of another body, without any thing between them, just as weight is; and this quality may be cognizable by our faculty of seeing alone, just as the pressure of a heavy body is by our feeling alone.

76
How optics came to be considered as a part of mechanical philosophy.

The first thing which made it probable that mechanical philosophy had any thing to do with the phenomena of optics, was the discovery of Mr Roemer, "that apparition was not instantaneous;" that some time elapsed between the illumination of a body and its being seen at a distance. He discovered, that it was not till 40 minutes after the sun illuminated one of Jupiter's satellites that it was seen by an inhabitant of this globe. If therefore a sun were just created, it would be 40 minutes before Jupiter would be illuminated by him, and 200 before the Georgian planet would be illuminated. Here then is motion. It is therefore highly probable that there is something moved; but it is still doubted whether this something, which we call LIGHT, is a matter emitted from the shining body, and moving with great velocity, and acting on and affected by other bodies, in the various phenomena of optics, or whether it is a *certain state* of a medium which is thus propagated, as we see that waves are propagated along the surface of water, or sonorous undulations through the mass of air, while the water or air itself is hardly moved out of its place. Either of these suppositions makes optics a legitimate branch of mechanical philosophy; and it is the philosopher's business to examine both by the received laws of motion, and see which of them gives consequences which tally with the phenomena. This has been done; and we imagine that a complete incompatibility has been demonstrated between the consequences of the undulations of an elastic medium, and the phenomena of optics; while the consequences of the other or vulgar notion on this subject are perfectly consistent with mechanical laws. There are some things in this hypothesis very far beyond our power to conceive distinctly; but they are all similar in this respect to many facts acknowledged by all; and there is no phenomenon that is inconsistent with the legitimate consequences of the hypothesis. This gives it great probability; and this probability is confirmed by many chemical facts, and by facts in the vegetable economy, which give strong and almost undeniable indications of light being a body capable of a chemical union with the other ingredients of sublunary bodies, and of being afterwards set at liberty under its own form, as the cause or medium of vision.

77
The nature of light is still undetermined.

78
But this does not affect the science of optics.

But these are questions similar to those about the cause of gravity, and totally unnecessary for establishing a complete theory of the optical phenomena, for explaining the nature of vision, the effects of optical instruments, the cause of colours, the phenomena of the rainbow, halos and parhelia, &c. &c. &c. Only all this theory is unconnected with the principles called mechanical.

79
The probable increase of the above extensive field of observation.

Such is the field of observation to the mechanical philosopher of the present day. We may hope to extend it, and by degrees apply its doctrines even to the unseen motions which take place in chemistry and physiology. But we must, in the first place, perfect our knowledge and description of the sensible motions and actions of bodies. Those of fluids still demand much investigation; and till these are thoroughly understood, it is not time to attempt penetrating further into the recesses of nature.

80
Investigation of the law that action is always equal and opposite to reaction.

In the prosecution of this study, it is found that every change which can be observed in the state of a body, with respect to motion by the action of another body, is accompanied by an equal and opposite change in the state of that other body. Thus, in the phenomena of gravitation, it is observed that the deflections of the sun and planets are mutual. The same thing is observed in the actions of magnets on each other and on iron; it is also observed in the attractions and repulsions of electrical bodies; and it also obtains in all the phenomena of impulse and of corporeal pressure. It is therefore an universal law of motion, that *action is always equal and opposite to reaction*: but this must be considered merely as a matter of fact, a contingent law of nature, like that of gravitation. The contrary is perfectly conceivable, and involves no contradiction. That this is so, is evident from the proceedings of philosophers, who in every new case make it their business to discover by experiment whether this law was observed or not. It was among the last discoveries made by Sir Isaac Newton in his examination of the celestial motions. This being the case, it should never be assumed as a principle of reasoning till its operation has been ascertained by observation.

81
The term *inertia* has occasioned much wrangling and misconception on this subject.

It has been owing to this improper procedure that much false reasoning has been introduced into mechanical philosophy, and particularly into the theory of impulsion or the communication of motion by impulse. In considering this subject, a term has been introduced which has occasioned much wrangling and misconception; we mean the term INERTIA. It serves indeed to abbreviate language, but it has often misled the judgement. When used with cautious attention to every circumstance, it expresses nothing but the necessity of a cause to the production of any effect: but it is generally used as expressing a quality inherent in matter, by which it *resists* any change of state, or by which it maintains its present state. Matter is said to be inert; and as every thing which changes the motion of a body is called a *force*, and as this inertia of A is supposed to change the motion of B, it is called *vis inertiæ*; and yet matter is said to be indifferent as to motion or rest, and to be inactive. These are

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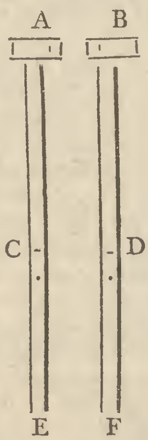
are surely very incongruous expressions. This obscure discourse has arisen from the poverty of all languages, which are deficient in original terms, and therefore employ figurative ones. Force, action, resistance, are all appropriated terms related to our own exertions; and some resemblance between the external effects of these exertions and the effects of the connecting qualities of natural bodies, has made us use them in our disquisitions on these subjects. And as we are conscious that, in order to prevent our being pushed by another from our place, we must resist, exerting force; and that our resistance is the reason why this other man has not accomplished his purpose, we say, that the quiescent body resists being put in motion, and that its inertia is discovered by the diminution made in the motion of the impelling body: and upon the authority of this *vis inertiæ* as a first principle, the phenomena of impulsion are explained, and the law of equal action and reaction is established.

But all this procedure is in contradiction to the rules of inductive logic; and the obscurity and confusion which has arisen from this original misconception, the consequent incongruity of language, and the aukward attempts that have been made to botch and accommodate it to the real state of things, have occasioned a dispute, and the only dispute, in natural philosophy which has not yet been settled, and never can be settled, while such misconceptions are allowed to remain.

82 Its proper meaning, with an example.

If the word *inertia* be taken as expressing not a quality of matter, but a law of human judgement respecting matter, as expressing our necessity of inferring the agency of a moving force whenever we observe a change of motion, all difficulties will vanish, and the equality of action and reaction will be inferred, as it should be, from the phenomena of collision. There will be inferred a *vis insita corpori impellenti*, not *quâ moventi*, but *quâ corpori;* and this inference will carry us through all the mysteries of corporeal action, as it conducted Sir Isaac Newton in his grand researches.



Let us just consider how we reason in a new case. Let A and B be two magnets fastened on the ends of two long wooden laths AE, BF, which turn horizontally on pivots C, D, like compass needles, with their north poles fronting each other, 12 inches apart; and let A be pushed towards B, so that it would move uniformly with the velocity of two inches in a second. The phenomena *which have been observed* are as follow: A will gradually diminish its velocity; and when it has advanced about nine inches, will stop completely. B, in the mean time will gradually acquire motion; and when it has advanced about nine inches, will have a velocity of about two inches per second, with which it will continue to move uniformly. Now what is inferred from these phenomena? Because the motion of A is gradually retarded, we infer that a retarding force, that is, a force in the direction BA, has acted on it. And since this would not have happened if B had not been there, and always happens when B is there, we infer that B is either its cause or the occasion of its action. The vulgar say that B repels A; so say the dynamists. The abettors of invisible fluids say, that a stream of fluid issuing from B impels A in the opposite direction. All naturalists agree in saying, that an active force connected with B has destroyed the motion of A, and consider this curious phenomenon as the indication and characteristic of a discovery. The same inference is made from the motion produced in B: it is considered by all as effected by a force exerted or occasioned by the presence of A; and the dynamists and the vulgar say that A *repels* B. And both parties conclude, from the equal changes made on both bodies, that the changing forces are equal; here acknowledging, that they *observe* an equality of action and reaction; and they add this to the other instances of the extent of this law of motion.

All this while no one thinks of the inertia or inactivity of B, but, on the contrary, conclude this to be a curious instance of its activity; and most people conclude that both bodies carry about with them a *vis insita* both when at rest and when in motion.

83 It is doubtful whether actual contact has ever been observed.

If other phenomena give unquestionable evidence that, in ordinary collisions, there is the same changes of motion, produced without mathematical contact, the same inferences must be drawn; and a scrupulous naturalist will doubt whether contact should make any change in our reasonings on the subject, and whether actual contact ever has been or can be observed. He will also be convinced, that while this is the general, or perhaps universal, process of nature in producing motion by impulse, all explanations of the action of bodies *è distanti*, by the intervention of ethers and other invisible fluids, are nothing but multiplying the difficulties; for in place of one fact, the approach of one magnet (for instance) to another, they substitute millions of unseen impulses, each of which equally needs an explanation. And if this fluid be supposed to produce its effects by any *peculiarity* in its constitution, as in the case of Newton's elastic ether proposed by him to explain gravitation, the hypothesis substitutes, in the most unqualified manner, millions of similar phenomena for the one to be explained; for there is the same want of a second fluid in order to produce that mutual recess of the particles of the ether which constitutes its elasticity.

84 The folly of supposing intervening ethers, &c.

85 The quality of bodies whereby they afford other bodies is insupportable by us.

And this seems to be the limit to our inquiries into all the classes of natural phenomena. We find the masses or the particles of matter endued in fact with qualities which affect the state of other particles or masses, at smaller or at greater distances from each other according to certain general rules or laws. This ultimate step in the constitution of things is inscrutable by us. It is arrogance in the highest degree for us to say, that because we do not comprehend how there is inherent in a body any quality by which another body may be affected at any distance from it, therefore no such quality *is possible*. It is no less so to say, that matter has no active property but that of moving other matter by impulse; and that because it may be so moved, and also by the agency of our own minds, therefore, when it is not moved by impulse, it is moved by minds. The same almighty FIAT which brought a particle of matter into existence could bring those qualities equally into existence; and the *how* in both is equally beyond our comprehension.

86 This should not, however, stop further inquiries.

But, on the other hand, we must guard against the incurious resting on this consideration as a stop to further inquiry. There may be species of matter possessed

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ſed of the mechanical powers, and which notwithſtanding is not cognifable by our ſenſes. All the properties of matter are not known to a perſon who is both deaf and blind; and beings poſſeſſed of more ſenſes may perceive matter where we do not; and many phenomena may really be produced by the action of intervening matter, which we, from indolence or from haſte, aſcribe to the agency of inherent forces. The induſtry of philoſophers has already diſcovered intermedia in ſome caſes. It is now certain that air is the conveyor of ſound, and it is almoſt certain that there is ſuch a thing as light. Let us therefore indulge conjectures of this kind, and examine the conjectures by the received laws of motion, and reject them when we find the ſmalleſt inconſiſtency; and always keep in mind that even the moſt coincident with the phenomena is ſtill but a poſſibility.

87 These obſervations are not phyſical, but metaphyſical.

We may conclude the whole of theſe obſervations with the remark, that theſe queſtions about the activity or inactivity of matter are not phyſical, but metaphyſical. Natural philoſophy, it is true, commonly takes it for granted that matter is wholly inactive; but it is not of any moment in phyſics whether this opinion be true or falſe; whether matter be acted on according to certain laws, or whether it act of itſelf according to the ſame laws, makes no difference to the natural philoſopher. It is his buſineſs to diſcover the laws which really obtain, and to apply theſe to the ſolution of ſubordinate phenomena: but whether theſe laws ariſe from the nature of ſome agent external to matter, or whether matter itſelf is the agent, are queſtions which may be above his comprehenſion, and do not immediately concern his proper buſineſs.

88 The above account points out the beſt method of ſtudy.

The account we have now given of natural philoſophy points out to us in the plaineſt manner the way in which the ſtudy muſt be proſecuted, and the helps which muſt be taken from other branches of human knowledge.

89 This method further explained and exemplified.

The cauſes, powers, forces, or by whatever name we chooſe to expreſs them, which produce the mechanical phenomena of the univerſe, are not obſerved, and are known to us only in the phenomena themſelves. Our knowledge of the mechanical powers of nature muſt therefore keep pace with our knowledge of the motions, and indeed is nothing different from it. In order to diſcover and determine the forces by which the moon is retained in her orbit round the earth, we muſt know her motions. To a terreſtrial ſpectator ſhe appears to deſcribe an ellipſe, having the earth in one focus; but, in the mean time, the earth is carried round the ſun, and the moon's real path, in abſolute ſpace, is a much more complicated figure. Till we know this figure, and the variations in the velocity with which it is deſcribed, we know nothing of the forces which actuate the moon in her orbit.

90 The meaning of ſome terms uſed in ſpeaking of the celeſtial motions.

When Newton ſays that the forces by which ſhe is retained in this elliptical orbit are directed to the earth, what does he mean? Only this, that the deflections from that uniform rectilineal motion which ſhe would otherwiſe have performed are always in this direction. In like manner, when he ſays that theſe forces are inverſely proportionate to the ſquares of her diſtances from the earth, he only means that the deflections made in equal times in different parts of her motion are in this proportion. Theſe deflections are conſidered as the characteriſtics and meaſures of the forces. We imagine that we have made all plain when we call this indicated cauſe a *tendency* to the earth; but we have no notion of this tendency to the earth different from the approach itſelf. This word tendency, ſo faſhionable among the followers of Sir Iſaac Newton, is perverted from its pure and original ſenſe. *Tendere verſus ſolem*, is, in the language of Rome, and alſo of Newton, *to go* towards the ſun; but we now uſe the words *tend*, *tendency*, to ſignify, not the *approach*, but the *cauſe* of this approach. And when called upon to ſpeak ſtill plainer, we deſert the ſafe paths of plain language, and we expreſs ourſelves by metaphor; ſpeaking of *niſus*, *conatus ſeſe mutua accedende*, *vis centripeta*, &c. When theſe expreſſions have become familiar, the original ſenſe of the word is forgotten, and we take it for granted that the words never had another meaning; and this metaphor, ſprung from the poverty of language, becomes a fruitful ſource of miſconception and miſtake. The only way to ſecure ourſelves againſt ſuch myſtical notions as are introduced by theſe means into philoſophy, is to have recourſe to the way in which we acquire the knowledge of theſe fancied powers; and then we ſee that their names are only names for phenomena, and that univerſal gravitation is only an univerſal mutual approach among the parts of the ſolar ſyſtem.

91 The abſurdity of reaſoning *a priori*.

There is one caſe in which we fondly imagine that we know the cauſe independent of the effect, and that we could have predicted the phenomenon *à priori*; we mean the caſe of impulſe: and hence it is that we are ſo prone to reduce every thing to caſes of impulſion, and that we have fallen upon all theſe ſubterfuges of ethers and other ſubtile fluids. But we might have ſaved ourſelves all this trouble; for after having, by much falſe reaſoning and gratuitous aſſumptions, ſhown that the phenomenon in queſtion *might have been produced* by impulſe, we are no nearer our purpoſe, becauſe that property by which matter in motion puts other matter in motion, is known to us only *by* and *in* the effect.

92 We know nothing of the immediate cauſes of motions except by a knowledge of the motions themſelves.

The fair and logical deduction from all this is, that we muſt not expect any knowledge of the powers of nature, the immediate cauſes of the motions of bodies, but by means of a knowledge of the motions themſelves; and that every miſtake in the motions is accompanied by a ſimilar miſtake in the cauſes. It is impoſſible to demonſtrate or explain the gravitation of the planets to him who is ignorant of the properties of the ellipſe, or the theory of gunnery to him who does not know the parabola.

93 A man cannot be a good natural philoſopher without being a mathematician.

A notion has of late gained ground, that a man may become a natural philoſopher without mathematical knowledge; but this is entertained by none who have any mathematics themſelves; and ſurely thoſe who are ignorant of mathematics ſhould not be ſuſtained as judges in this matter. We need only appeal to fact. It is only in thoſe parts of natural philoſophy which have been mathematically treated, that the inveſtigations have been carried on with certainty, ſucceſs, and utility. Without this guide, we muſt expect nothing but a ſchool-boy's knowledge, reſembling that of the man who takes up his religious creed on the authority of his prieſt, and can neither give a reaſon for what he imagines that he believes,

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lieves, nor apply it with confidence to any valuable purpose in life. We may read and be amused with the trifling or vague writings of a Nollet, a Ferguson, or a Priestley; but we shall not understand, or profit by the truths communicated by a Newton, a D'Alembert, or De la Grange.

These observations, on the other hand, show us the nature of the knowledge which may be acquired, and the rank which natural philosophy holds among the sciences.

94 The motions of bodies, the only objects of observation, are subjects of pure mathematical disquisition.

Motions are the real and only objects of our observation, the only subjects of our discussion. In motion are included no ideas but those of space and time, the subjects of pure mathematical disquisition. As soon, therefore, as we have discovered the fact, the motion, all our future reasonings about this motion are purely mathematical, depending only on the affections of figure, number, and proportion, and must carry along with them that demonstration and irresistible evidence which is the boast of that science. To this are we indebted for that accuracy which is attained, and the progress which has been made in some branches of mechanical philosophy; for when the motions are distinctly and minutely understood, and then considered only as mathematical quantities, independent of all physical considerations, and we proceed according to the just rules of mathematical reasoning, we need not fear any intricacy of combination or multiplicity of steps; we are certain that truth will accompany us, even though we do not always attend to it, and will emerge in our final proposition, in the same manner as we see happen in a long and intricate algebraic analysis.

95 Mechanical philosophy thus cultivated is a demonstrative science.

Mechanical philosophy, therefore, which is cultivated in this way, is not a system of probable opinions, but a *disciplina accurata*, a demonstrative science. To possess it, however, in this form, requires considerable preparation. The mere elements of geometry and algebra are by no means sufficient. Newton could not have proceeded *sine* "*sua mathesi facem preferente*;" and, in creating a new science of physics, he was obliged to search for and discover a new source of mathematical knowledge.

96 The lamentable decay of mathematics in Britain,

It is to be lamented that the taste for the mathematical sciences has so prodigiously declined in this country of late years; and that Britain, which formerly took the lead in natural philosophy, should now be the country where they are least cultivated. Few among us know more than a few elementary doctrines of equilibrium: while, on the continent, we find many authors who cultivate the Newtonian philosophy with great assiduity and success, and whose writings are consulted as the fountains of knowledge by all our countrymen who have occasion to employ the discoveries in natural philosophy in the arts of life. It is to the foreign writers that we have recourse in our seminaries, even for elementary treatises; and while the continent has supplied us with most elaborate and useful treatises on various articles, in physical astronomy, practical mechanics, hydraulics, and optics, there has not appeared in Britain half a dozen treatises worth consulting for these last forty years; and this notwithstanding the unparalleled munificence of our present sovereign, who has given more liberal patronage to the cultivators of mathematical philosophy, and indeed of science in general, than any prince in Europe. The magnificent establishments of Louis XIV. originated from his insatiable ambition and desire of universal influence, directed by the sagacious Colbert. And his patronage being exerted according to a regular plan in the establishment of pensioned academics, and in procuring the combined efforts of the *most eminent* of all countries, his exertions made a conspicuous figure, and filled all Europe with his eulogists. But all this was done without the smallest self-denial, or retrenchment of his own pleasures, the expences being furnished out of the public revenues of a great and oppressed nation; whereas the voyages of discovery, the expensive observations and geodetical operations in Britain, and the numberless unheard-of pensions and encouragements given to men of science and activity, were all furnished out of the private estate of our excellent sovereign, who seems to delight in repaying, by every service in his power, the attachment of a loyal and happy nation. It is therefore devoutly to be wished that his patriotic efforts were properly seconded by those whom they are intended to serve, and that the taste for the mathematical sciences may again turn the eyes of Europe to this country for instruction and improvement. The present seems a most favourable era, while the amazing advances in manufactures of every kind seem to call aloud for the assistance of the philosopher. What pleasure would it have given to Newton or Halley to have seconded the ingenious efforts of a Watt, a Boulton, a Smeaton, an Arkwright, a Dollond? and how mortifying is it to see them indebted to the services of a Belidor, a Bossut, a Clairaut, a Boscovich?

97 notwithstanding the amplest encouragement from the crown.

We hope to be pardoned for this digression, and return to our subject.

98 Mechanical philosophy is almost wholly a mathematical study.

It appears from what has been said, that mechanical philosophy is almost wholly a mathematical study, and that it is to be successfully prosecuted only under this form: but in our endeavours to initiate the young beginner, it will be often found to require more steadiness of thought than can generally be expected for keeping the mind engaged in such abstract speculations. The object presented to the mind is not readily apprehended with that vivacity which is necessary for enabling us to reason upon it with clearness and steadiness, and it would be very desirable to have some means of rendering the conception more easy, and the attention more lively.

99 Experiments are, however, necessary to insure the attention of young minds.

This may be done by exhibiting to the eye an experiment, which, though but a single fact, gives us a sensible object of perception, which we can contemplate and remember with much more steadiness than any mere creature of the imagination. We could, by an accurate description, give such a conception of a room that the hearer should perfectly comprehend our narration of any occurrence in it: but one moment's glance at the room would be infinitely better. It is usual therefore to employ experiments to assist the imagination of the beginner; and most courses of natural philosophy are accompanied by a series of such experiments. Such experiments, connected by a slight train of argumentative discourse, may even serve to give a notion of the general doctrines, sufficient for an elegant amusement, and even tending to excite curiosity and engage in a serious prosecution of the study. Such are the usual courses which go by the name of experimental philosophy: but this is

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is a great mifapplication of the term; fuch courfes are little more than *illuftrations* of known doctrines by experiments.

100 Experimental philofophy defined and explained.

EXPERIMENTAL PHILOSOPHY is the inveftigation of general laws, as yet unknown, by experiment; and it has been obferved, under the article PHILOSOPHY, that this is the moft infallible (and indeed the fole) way of arriving at the knowledge of them. This is the *Novum Organum Scientiarum* ftrongly recommended by Lord Bacon. It was new in his time, though not altogether without example; for it is the procedure of nature, and is followed whenever curiofity is excited. There was even extant in his time a very beautiful example of this method, viz. the Treatife of the Loadftone, by Dr Gilbert of Colchefter; a work which has hardly been excelled by any, and which, when we confider its date, about the year 1580, is really a wonderful performance.

The moft perfect model of this method is the Optics of Sir Ifaac Newton. Dr Black's Effay on Magnefia is another very perfect example. Dr Franklin's Theory of Electricity is another example of great merit. That the inveftigation is not complete, nor the conclufions certain, is not an objection. The method is without fault; and a proper direction is given to the mind for the experiments which are ftill neceffary for eftablifhing the general laws.

101 A good treatife on the method of inquiry by experiment very neceffary.

It were much to be wifhed that fome perfon of talents and of extenfive knowledge would give a treatife on the method of inquiry by experiment. Although many beautiful and fuccefsful examples have been given as particular branches of inquiry, we have but too many inftances of very inaccurate and inconclufive inveftigations. Experiments made at random, almoft without a view, ferve but little to advance our knowledge. They are like fhapelefs lumps of ftone merely detached from the rock, but ftill wanting the fkill of the builder to felect them for the different purpofes which they may chance to ferve; while well-contrived experiments are blocks cut out by a fkilful workman, according as the quarry could furnifh them, and of forms fuited to certain determined ufes in the future edifice. Every little feries of experiments by Margraaf terminates in a general law, while hardly any general conclufion can be drawn from the numberlefs experiments of Pott. Lord Bacon has written much on this fubject, and with great judgement and acutenefs of diftinction; but he has exceeded in this, and has fatigued his readers by his numerous rules; and there is in all his philofophical works, and particularly in this, a quaintnefs and affectation that greatly obfcure his meaning, fo that this moft valuable part of his writings is very little read.

102 An objection to experimental inquiry.

A formidable objection has been made to this method of inquiry. Since a phyfical law is only the expreffion of a general fact, and is eftablifhed only in confequence of our having obferved a fimilarity in a great number of particular facts; and fince the great rule of inductive logic is to give the law no greater extent than the induction on which it is founded—how comes it that a few experiments muft be received as the foundation of a general inference? This has been anfwered in very general terms in the article PHILOSOPHY. But it will be of ufe to confider the fubject a little more particularly. Our obfervations on this fubject are taken from the differtation on evidence by Dr Campbell in his Philofophy of Rhetoric.

103 The objection anfwered, with examples fhowing the nature and certainty of this mode of inquiry.

An attentive confideration of the objects around us, will inform us that they are generally of a complicated nature, not only as confifting of a complication of thofe qualities of things called accidents, fuch as gravity, mobility, colour, figure, folidity, which are common to all bodies; but alfo as confifting of a mixture of a variety of fubftances, very different in their nature and properties; and each of thefe is perhaps compounded of ingredients more fimple.

Moreover, the farther we advance in the knowledge of nature, we find the more reafon to be convinced of her conftancy in all her operations. Like caufes have always produced like effects, and like effects have always been preceded by like caufes. Inconftancy fometimes appears in Nature's works at *firft fight*; but a more refined experience fhows us that this is but an appearance, and that there is no inconftancy: and we explain it to our fatisfaction in this way.

Moft of the objects being of a complicated nature, we find, on an accurate fcrutiny, that the effects afcribed to them ought often to be folely afcribed to one or more of thefe component parts, while the others either do not contribute to them, or hinder their production; and the variety of nature is fo great, that hardly any two individuals of the fame fpecies are in every refpect like any other. On all thefe accounts we expect diffimilitudes in the phenomena accompanying perfectly fimilar treatment of different fubjects of the fame kind; but we find, that whenever we can be affured that the two fubftances are perfectly alike, the phenomena arifing from fimilar treament are the fame: and long and extenfive obfervation teaches us, that there are certain circumftances which infure us in the perfect fimilarity of conftitution of fome things. Whenever we obferve the effect of any natural agent on one, and but one, of thefe, we invariably expect that the fame will be produced on any other.

Should a botanift meet with a plant new to him, and obferve that it has feven monopetalous flowers, he will conclude with the utmoft confidence that every plant of this fpecies will have monopetalous flowers; but he will not fuppofe that it will have feven, and no more than feven, flowers. Now thefe two facts feem to have no difference to warrant fuch a difference in the conclufion; which may therefore feem capricious, fince there is but one example of both.

But it is not from this example only that he draws the conclufion. Had he never before taken notice of any plant, he would not have reafoned at all from thefe remarks. But his mind runs immediately from this unknown fpecies to all the known fpecies of this genus, and to all the genera of the fame order; and having experienced in the *figure* of the flower an uniformity in every fpecies, genus, and order, which admits of no exception, but, in the *number* of flowers, a variety as boundlefs as are the circumftances of foil, climate, age, and culture, he learns to mark the difference, and draws the above-mentioned conclufions. Thus we learn, that *perfect* uniformity is not to be expected in any inftance whatever, becaufe in no inftance is the fimplicity of conftitution fufficiently great to give us affurance of perfect uniformity in the circumftances of the cafe; and the utmoft most that our experience can teach us is a quick discrimination of those circumstances which produce the occasional varieties.

The nearer that our investigations carry us to the knowledge of *elementary* natures, the more are we convinced by general experience of the uniformity of the operations of real elements; and although it may perhaps be impossible for us ever to arrive at the knowledge of the simplest elements of any body, yet when any thing *appears* simple, or rather so exactly uniform, as that we have invariably observed it to produce similar effects on discovering any *new* effect of this substance, we conclude, from a general experience of the efficient, a like constancy in the energy as to the rest. Fire consumes wood, melts lead, and hardens clay. In these instances it acts uniformly, but not in these only. We have always found, that whatever of any species is consumed by it in one instance, has been consumed by it on trial at any time. If therefore a trial be made for the first time of its influence on any particular substance, he who makes it is warranted to conclude that the effect, whatever it may be, is a faithful representative of its effects on this substance in all past and future ages. This conclusion is not founded on this single instance, but upon this instance combined with the general experience of the regularity of this element in its operations.

This general conclusion, therefore, drawn from one experiment, is by no means in opposition to the great rule of inductive logic, but, on the contrary, it is the most general and refined application of it. General laws are here the real subject of consideration; and a law still more general, viz. *that nature is constant in all its operations*, is the inference which is here applied as a principle of explanation of a phenomenon which is itself a general law, viz. *that nature is constant in this operation.*

The foundation of this general inference from one experiment being so firmly established, it is evident that experiments must be an infallible method of attaining to the knowledge of nature; and we need only be solicitous that we proceed in a way agreeable to the great rule of inductive logic; that is, the subject must be cleared of every accidental and *unknown* circumstance, and put into a situation that will reduce the interesting circumstance to a state of the greatest possible simplicity. Thus we may be certain that the event will be a faithful representative of every similar case: and unless this be done in the preparation, nothing can result from the most numerous experiments but uncertainty and mistakes.

104 Mathematics do not supersede the use of experiment.

The account which has been given of mechanical philosophy would seem to indicate that experiment was not of much use in the farther prosecution of it. The two laws of motion, with the assistance of mathematics, seem fully adequate to the explanation of every phenomenon; and so they are to a *certain degree.* But this degree is as yet very limited. Our mathematical knowledge, great as it is in comparison with that of former times, is still insufficient for giving accurate solutions even of very simple (comparatively speaking) questions. We can tell, with the utmost precision, what will be the motions of two particles of matter, or two bodies, which act on each other with forces proportioned to the squares of the distances inversely; but if we add a third particle, or a third body, acting by the same law, the united science of all Europe can only give an approximation to the solution.

105 Experiment is often the only resource.

What is to be done then in the cases which come continually before us, where millions of particles are acting at once on each other in every variety of situation and distance? How shall we determine, for instance, the motion of water through a pipe or sluice when urged by a piston or by its own weight? what will be its velocity and direction? It is impossible, in the present state of mathematical knowledge, to tell with any precision or certainty. And here we must have recourse to experiment. But if this be the case, must the experiment be made in every possible variety of situation, depth, figure, pressure? or is it possible to find out any general rules, founded on the general laws of motion, and rationally deduced from them? Or, if this cannot be accomplished, will experiment itself furnish any general coincidences which show such mutual dependences, that we may consider them as indications of general principles, though subordinate, complicated, and perhaps inscrutable? This can be discovered by experiment alone.

106 Accurate experiments cannot always be made.

The attention of philosophers has been directed to each of these three chances, and considerable progress has been made in them all. Numerous experiments have been made, almost sufficient to direct the practice in many important cases, without the help of any rule or principle whatever. But there are many cases, and these of by far the greatest importance, such as the motion of a ship impelled by the winds, resisted by the water, and tossed by the waves, where distinct experiments cannot be made.

107 Example of the necessity of experiment.

Newton, Bernouilli, d'Alembert, and others, have laboured hard to deduce from the laws of motion rules for determining what may be called the *average* motion of water in these circumstances, without attempting to define the path or motion of any individual particle; and they have actually deduced many rules which have a great degree of probability. It may here be asked, why do you say *probability?* the rules, as far as they go, should be *certain.* So they are: they are strict deductions from their premisses. But the premisses are only *suppositions*, of various degrees of probability, assumed in order to simplify the circumstances of the case, and to give room for mathematical reasoning; therefore these deductions, these rules, must be examined by experiment. Some of the suppositions are such as can hardly be refused, and the rules deduced from them are found to tally precisely with the phenomena. Such is this, "that the velocities of issuing water in similar circumstances are in the sub-duplicate ratio of the pressures." And this rule gives a most important and extensive information to the engineer. Other suppositions are more gratuitous, and the rules deduced from them are less coincident with the phenomena. The patient and sagacious Newton has repeatedly failed in his attempts to determine what is the *absolute velocity* of water issuing from a hole in the bottom of a vessel when urged by its weight alone, and the attempts of the others have hardly succeeded better. Experiment is therefore absolutely necessary on this head.

Those who have aimed at the discovery of *rules* purely experimental on this subject, have also been pretty successful; and the Chevalier Buat has, from a comparison

Experimental Philosophy. fon of an immenfe variety of experiments made by himfelf and various authors, deduced an empirical rule, which will not be found to deviate from truth above one part in ten in any cafe which has yet come to our knowledge.

This inftance may ferve to fhow the ufe of experiments in mechanical philofophy. It is proper in all cafes by way of illuftration; and it is abfolutely neceffary in moft, either as the foundation of a characteriftic of a particular clafs of phenomena, or as argument in fupport of a particular doctrine. Hydroftatics, hydraulics, pneumatics, magnetifm, electricity, and optics, can hardly be ftudied in any other way; and they are at prefent in an imperfect ftate, and receiving continual improvement by the labours of experimental philofophers in all quarters of the world.

108 The advantages derived from the ftudy of philofophy

Having in the preceding paragraphs given a pretty full enumeration of the different fubjects which are to be confidered in the ftudy of natural philofophy, it will not be neceffary to fpend much time in a detail of the advantages which may reafonably be expected from a fuccefsful profecution of this ftudy. It ftands in no need of panegyric: its intimate connection with the arts gives it a fufficient recommendation to the attention of every perfon. It is the foundation of many arts, and it gives liberal affiftance to all. Indebted to them for its origin and birth, it has ever retained its filial attachment, and repaid all their favours with the moft partial affection.

109 in navigation,

To this fcience the navigator muft have recourfe for that aftronomical knowledge which enables him to find his place in the tracklefs ocean; and although very fmall fcraps of this knowledge are fufficient for the mere pilot, it is neceffary that the ftudy be profecuted to the utmoft by fome perfons, that the unlearned pilot may get that fcanty pittance which muft direct his routine. The few pages of tables of the fun's declination, which he ufes every day to find his latitude, required the fucceffive and united labours of all the aftronomers of Europe to make them tolerably exact: and in order to afcertain his longitude with precifion, it required all the genius of a Newton to detect the lunar irregularities, and bring them within the power of the calculator; and, till this was done, the refpective pofition of the different parts of the earth could not be afcertained. Vain would have been the attempt to do this by geodætical furveys independent of aftronomical obfervation. It is only from the moft refined mechanics that we can hope for fure principles to direct us in the conftruction and management of a fhip, the boaft of human art, and the great means of union and communication between the different quarters of the globe.

110 in architecture,

A knowledge of mechanics not much inferior to this is neceffary for enabling the architect to execute fome of his greateft works, fuch as the erection of domes and arches, which depend on the niceft adjuftment of equilibrium. Without this he cannot unite economy with ftrength; and his works muft either be clumfy maffes or flimfy fhells.

111 in gunnery and other engines, &c.

The effects of artillery cannot be underftood or fecured without the fame knowledge.

The whole employment of the engineer, civil or military, is a continual application of almoft every branch of mechanical knowledge; and while the promifes of a Smeaton, a Watt, a Belidor, may be confided in as if already performed, the numberlefs failures and difappointments in the moft important and coftly projects fhow us daily the ignorance of the pretending crowd of engineers.

The microfcope, the fteam-engine, the thunder-rod, are prefents which the world has received from the natural philofopher; and although the compafs and telefcope were the productions of chance, they would have been of little fervice had they not been ftudied and improved by Gilbert, Halley, and Dollond.

But it is not in the arts alone that the influence of natural philofophy is perceived: it lends its aid to every fcience, and in every ftudy.

It is often neceffary to have recourfe to the philofopher in difputes concerning property; and many examples might be given where great injuftice has been the confequence of the ignorance of the judges. Knowledge of nature might have prevented many difgraceful condemnations for forcery. 112 in law,

The hiftorian who is ignorant of natural philofophy eafily admits the miraculous into his narrations, accompanies thefe with his reflections, draws confequences from them, and fills his pages with prodigies, fables, and abfurdity. 113 in hiftory,

It is almoft needlefs to fpeak of the advantages which will accrue to the phyfician from this ftudy. So clofe is the connection between it and medicine, that our language has given but one name to the naturalift and to the medical philofopher. Indeed, the whole of his ftudy is a clofe obfervation of the laws of material nature, in order to draw from them precepts to direct his practice in the noble art of healing. During the immaturity of general knowledge, while natural philofophy was the only ftudy which had acquired any juft pretenfion to certitude either in its principles or method of inveftigation, the phyficians endeavoured to bring the objects of their ftudy within its province, hoping by this means to get a more diftinct view of it; and they endeavoured to explain the abftrufe phenomena of the animal functions by reducing them all to motions, vibrations, collifions, impulfes, hydroftatic and hydraulic preffures and actions, with which the mechanical philofophers were fo ardently occupied at that time. But unfortunately their acquaintance with nature was then very limited, and they were but little habituated to the rules of juft reafoning; and their attempts to explain the economy of animal life by the laws of mechanics did them but little fervice either for the knowledge of difeafes or of the methods of cure. The mechanical theories of medicine, which had confiderable reputation about the end of the 17th century, were many of them very ingenious, and had an impofing appearance of fymmetry and connection; but are now forgotten, having all been formed on the narrow fuppofition that matter was fubject only to mechanical laws. 114. in medicine,

But the difcovery of error diminifhes the chance of again going wrong, efpecially when the caufe of error has been difcovered, and the means pointed out of detecting the miftakes; and the vital principle muft combine its influence with, or operate on, the properties of rude matter. It appears therefore evident that a knowledge of the mechanical laws of the material world is not only a convenient, but a neceffary, accomplifhment

to

to the physician. We are fully justified in this opinion, by observing medical authors of the present day introducing into medicine theories borrowed from mechanical philosophy, which they do not understand, and which they continually misapply. Appearance of reasoning frequently conceals the errors in principle, and seldom fails to mislead.

115 in religion, But there is no class of men to whom this science is of more service than to those who hold the honourable office of the teachers of religion. Their knowledge in their own science, and their public utility, are prodigiously hurt by ignorance of the general frame and constitution of nature; and it is much to be lamented that this science is so generally neglected by them, or considered only as an elegant accomplishment: nay, it is too frequently shunned as a dangerous attainment, as likely to unhinge their own faith, and taint the minds of their hearers. We hope, however, that few are either so feebly rooted in the belief of the great doctrines of religion as to fear this, or of minds so base and corrupted as to adopt and inculcate a belief which they have any suspicion of being ill-founded. But many have a sort of horror at all attempts to account for the events of nature by the intervention of general causes, and think this procedure derogatory to the Divine nature, and inconsistent with the doctrine of his particular providence; believing, that "a sparrow does not fall to the ground without the knowledge of our heavenly Father." Their limited conceptions cannot perceive, that, in forming the general law, the Great Artist did at one glance see it in its remotest and most minute consequence, and adjust the vast assemblage so as completely to answer every purpose of His providence. There never was a more eager enquirer into the laws of nature, or more ardent admirer of its glorious Author, than the Hon. Robert Boyle. This gentleman says, that he will always think more highly of the skill and power of that artist who should construct a machine, which, being once set a going, would of itself continue its motion for ages, and from its inherent principles continue to answer all the purposes for which it was first contrived, than of him whose machine required the continual aid of the hand which first constructed it. It is owing to great inattention that this aversion to the operation of secondary causes has any influence on our mind. What do we mean by the introduction of secondary causes? How do we infer the agency of any cause whatever? Would we ever have supposed any cause of the operations of nature, had they gone on without any order or regularity? Or would such a chaos of events, any more than a chaos of existences, have given us any notion of a forming and directing hand? No surely. We see the hand of God in the regular and unvaried course of nature, only because it is regular and unvaried. The philosopher expresses this by saying, that the phenomena proceed by unalterable laws. Greatly mistaken therefore are they who think that we supersede the existence of mind and of providence when we trace things to their causes. A physical law being an unvaried fact, is an indication, and the strongest possible indication, of an unerring mind, who is incapable of change, and must do to day what He always did: for to change is to deviate from what is best *. The operations of unerring mind will therefore be regular and invariable. Physical laws, therefore, or secondary causes, are the best proofs of unerring wisdom. Such regularity of conduct is universally considered as an indication of wisdom among men. The wise man is known by the constancy of his conduct, while no man can depend on the future conduct of a fool.

* *Ferguson's Lectures on Ethics.*

And what astonishing evidences of wisdom do we not observe in the general laws of the material world? They will ever be considered by the intelligent philosopher as the most glorious display of inconceivable wisdom, which has been able, by means so few and so simple, to produce effects which by their grandeur astonish our feeble understandings, and by their inexhaustible variety elude all possibility of enumeration.

While the teachers of religion remain ignorant of the beautiful laws of nature, the great characteristics of the wisdom and goodness of the Almighty Creator, their hearers are deprived of much sublime pleasure; God is robbed of that praise which he would have received from an enlightened people; and the only worship he receives is tainted with mean notions of his attributes, and groundless fears of his power.

But besides these advantages which accrue to different classes of men from this study, there are some effects which are general, and are too important to be passed over unnoticed.

That spirit of dispassionate experimental enquiry which has so greatly promoted this study, will carry with it, into every subject of enquiry, that precision and that constant appeal to fact and experience which characterize it. And we may venture to assert, that the superior good order and method which distinguish some of the later productions in other sciences, have been in a great measure owing to this mathematical spirit, the success of which in natural philosophy has gained it credit, and thus given it an unperceived influence even over those who have not made it their study. 116 and in other sciences.

The truths also which the naturalist discovers are such as do not in general affect the passions of men, and have therefore a good chance of meeting with a candid reception. Those whose interest it is to keep men in political or religious ignorance, cannot easily suspect bad consequences from improvements in this science; and if they did, have hardly any pretext for checking its progress. And discoveries accustom the mind to novelty; and it will no longer be startled by any consequences, however contrary to common opinion. Thus the way is paved for a rational and discreet scepticism, and a free enquiry on other subjects. Experiment, not authority, will be considered as the test of truth; and under the guidance of fair experience we need fear no ill as long as the laws of nature remain as they are. 117 More general advantages of philosophy.

Lastly, since it is the business of philosophy to describe the phenomena of nature, to discover their causes, to trace the connection and subordination of these causes, and thus obtain a view of the whole constitution of nature; it is plain that it affords the surest path for arriving at the knowledge of the great cause of all, of God himself, and for forming proper conceptions of him and of our relations to him: notions infinitely more just than can ever be entertained by the careless spectator of his works. Things which to this man appear solitary and detached, having no other connection, Experimental Philofophy

tion with the reft of the univerfe but the fhadowy and fleeting relation of co-exiftence, will, to the diligent philofopher, declare themfelves to be parts of a great and harmonious whole, connected by the general laws of nature, and tending to one grand and beneficent purpofe. Such a contemplation is in the higheft degree pleafant and cheering, and cannot fail of impreffing us with the wifh to co-operate in this glorious plan, by acting worthy of the place we hold among the works of God, and with the hopes of one day enjoying all the fatisfaction that can arife from confcious worth and confummate knowledge; and this is the worfhip which God will approve. "This univerfe (fays Boyle) is the magnificent temple of its great Author; and man is ordained, by his powers and qualifications, the high prieft of nature, to celebrate divine fervice in this temple of the univerfe."

PHYSIOGNOMONICS, among phyficians, denote fuch figns as, being taken from the countenance, ferve to indicate the ftate, difpofition, &c. both of the body and mind: and hence the art of reducing thefe figns to practice is termed *phyfiognomy*.

PHYSIOGNOMY

1 Various definitions of phyfiognomy ancient and modern.

IS a word formed from the Greek φυσις *nature*, and γινωσκω *I know*. It is the name of a fcience which occupied much of the attention of ancient philofophers, and which, fince the revival of learning, has in a great degree been difregarded. Till of late it has feldom in modern times been mentioned, except in conjunction with the exploded arts of magic, alchemy, and judicial aftrology. Within the laft two centuries, no doubt, the bounds of human knowledge have been greatly extended by means of the patient purfuit of fact and experiment, inftead of the hafty adoption of conjecture and hypothefis. We have certainly difcovered many of the ancient fyftems to be merely creatures of imagination. Perhaps, however, in fome inftances, we have decided too rapidly, and rejected real knowledge, which we would have found it tedious and troublefome to acquire. Such has been the fate of the fcience of phyfiognomy; which certainly merits to be confidered in a light very different from alchemy and thofe other fanciful ftudies with which it had accidentally been coupled. The work lately publifhed by M. Lavater on the fubject has indeed excited attention, and may perhaps tend to replace phyfiognomy in that rank in the circle of the fciences to which it feems to be intitled.

It does not appear that the ancients extended the compafs of phyfiognomy beyond *man*, or at leaft animated nature: But the ftudy of that art was revived in the middle ages, when, mifled probably by the comprehenfivenefs of the etymological meaning of the word, or incited by the prevalent tafte for the marvellous, thofe who treated of the fubject ftretched the range of their fpeculation far beyond the ancient limits. The extenfion of the fignification of the term was adopted univerfally by thofe naturalifts who admitted the theory of fignatures (fee SIGNATURE); and phyfiognomy came thus to mean, the knowledge of the *internal* properties of *any* corporeal exiftence from the *external* appearances. Joannes Baptifta Porta, for inftance, who was a phyfiognomift and philofopher of confiderable eminence, wrote a treatife on the phyfignomy of *plants (philognomonica)*, in which he employs phyfiognomy as the generic term. There is a treatife likewife *De Phyfiognomia Avium*, written we believe by the fame perfon. In the *Magia Phyfiognomica* of Gafpar Schottus, *phyfiognomia humana* is made a *fubdivifion* of the fcience.

Boyle too adopts the extenfive fignification mentioned, which indeed feems to have been at one time the ufual acceptation of the word (A). At prefent phyfiognomy feems to mean no more than "a knowledge of the moral character and extent of intellectual powers of human beings, from their external appearance and manners." In the Berlin Tranfactions for the years 1769 and 1770 there appears a long controverfial difcuffion on the fubject of the *definition* of phyfiognomy between M. Pernetty and M. Le Cat, two modern authors of fome note. Pernetty contends that *all knowledge whatever* is phyfiognomy; Le Cat confines the fubject to the *human face*. Neither feems to have hit the medium of truth. Soon after the celebrated book of Lavater appeared. He indeed defines phyfiognomy to be, "the art of difcovering the *interior* of *man* by means of his *exterior*; but in different paffages of his work he evidently favours the extended fignification of Pernetty. This work gave occafion to M. Formey's attack upon the fcience itfelf in the fame Berlin Tranfactions for 1775. Formey ftrenuoufly controverts the extent affigned by Lavater to his favourite fcience.

Before the era of Pythagoras the Greeks had little or no fcience, and of courfe could not be fcientifical phyfiognomifts. Phyfiognomy, however, was much cultivated in Egypt and India; and from thefe countries the fage 2

2 Pythagoras probably brought this fcience to Greece.

(A) They'll find i' the phyfiognomies
O' th' planets all men's deftinies. HUDIBRAS.

sage of Samos probably introduced the rudiments of this science, as he did those of many others, generally deemed more important, into Greece.

3 It was a profession in the time of Socrates.

In the time of Socrates it appears even to have been adopted as a profession. Of this the well-known anecdote of the decision of Zopyrus, on the real character of Socrates himself, judging from his countenace, is sufficient evidence. Plato mentions the subject; and by Aristotle it is formally treated of in a book allotted to the purpose.

It may be worth while to give a brief outline of Aristotle's sentiments on the subject.

4 General outline of Aristotle's opinions on this subject.

Physiognomy, he in substance observes, had been treated of in three ways: Some philosophers classed animals into genera, and ascribed to each genus a certain mental disposition corresponding to their corporeal appearance. Others made a farther distinction of dividing the genera into species. Among men, for instance, they distinguished the Thracians, the Scythians, the Egyptians, and whatever nations were strikingly different in manners and habits, to whom accordingly they assigned the distinctive physiognomical characteristics. A third set of physiognomists judged of the actions and manners of *the individual*, and presumed that certain manners proceeded from certain dispositions. But the method of treating the subject adopted by Aristotle himself was this: A peculiar form of body is invariably accompanied by a peculiar disposition of mind; a human intellect is never found in the corporeal form of a beast. The mind and body reciprocally affect each other: thus in intoxication and mania the mind exhibits the affections of the body; and in fear, joy, &c. the body displays the affections of the mind.

From such facts he argues, that when in man a particular bodily character appears, which by prior experience and observation has been found uniformly accompanied by a certain mental disposition, with which therefore it must have been necessarily connected; we are intitled in all such cases to infer the disposition from the appearance. Our observations, he conceives, may be drawn from other animals as well as from men: for as a lion possesses one bodily form and mental character, a hare another, the corporeal characteristics of the lion, such as strong hair, deep voice, large extremities, discernible in a human creature, denote the strength and courage of that noble animal; while the slender extremities, soft down, and other features of the hare, visible in a man, betray the mental character of that pusillanimous creature.

Upon this principle Aristotle treats of the corporeal features of man, and the correspondent dispositions, so far as observed: he illustrates them by the analogy just mentioned, and in some instances attempts to account for them by physiological reasoning.

At the early period in which Aristotle wrote, his theory, plausible certainly, and even probable, displays his usual penetration and a considerable degree of knowledge. He distinctly notices individual physiognomy, national physiognomy, and comparative physiognomy. The state of knowledge in his time did not admit of a complete elucidation of his general principles; on that account his enumeration of particular observations and precepts is by no means so well founded or so accurate as his method of study. Even his style, concise and energetic, was inimical to the subject; which, to be made clearly comprehensible, must require frequent paraphrases. Aristotle's performance, however, such as it is, has been taken as the groundwork and model of every physiognomical treatise that has since appeared.

The imitators of this great man in the 16th and 17th centuries have even copied his language and manner, which are sententious, indiscriminate, and obscure. His comparative physiognomy of men with beasts has been frequently though not universally adopted. Besides his treatise expresly on the subject, many incidental observations on physiognomy will be found interspersed through his other works, particularly in his history of animals.

5 Theophrastus's ethic characters form an important branch of physiognomy.

Next after Aristotle, his disciple and successor Theophrastus would deserve to be particularly mentioned as a writer on the subject in question. His ethic characters, a singular and entertaining performance, composed at the age of 99, form a distinct treatise on a most important branch of physiognomy, *the physiognomy of manners*: but the translations and imitations of La Bruyere are so excellent, that by referring to them we do greater justice than would otherwise be in our power, both to Theophrastus and to our readers. We cannot, however, omit observing, that the accuracy of observation and liveliness of description displayed in the work of Theophrastus will preserve it high in classical rank, while the science of man and the prominent characteristics of human society continue to be objects of attention.

6 Other Greek authors on this subject.

Polemon of Athens, Adamantius the sophist, and several others, wrote on the subject about the same period. Lately there was published a collection of all the Greek authors on physiognomy: the book is intitled, *Physiognomiæ veteris scriptores Græci, Gr. et Lat. à Franzio Alteub.* 1780, 8vo. From the number of these authors, it appears that the science was much cultivated in Greece; but the professors seem soon to have connected with it something of the marvellous. This we have cause to suspect from the story told by Apion of Apelles: *Imaginem adeo similitudinis indiscretæ pinxit, ut (incredibile dictu) Apion Grammaticus Scriptum reliquerit quemdam ex facie hominum addivinantem (quos melaposcopos vocant) ex iis dixisse aut futuræ mortis annos, aut præteritæ* *. The noviciates of the Pythagorean school were subjected to the physiognomic observation of their teachers, and it is probable the first physiognomists by profession among the Greeks were of this sect. They, too, to whom, from the nature of their doctrines and discipline, mystery was familiar, were the first, it is likely, who exposed the science of physiognomy in Greece to disgrace, by blending with it the art of divination.

7 The science was then coupled with something of the marvellous.

* *Pliny Nat. Hist.* lib. 35. § 35. par. 39.

8 The observations of Roman and other writers.

From the period of which we have been treating to the close of the Roman republic, nothing worthy of remark occurs in the literary history of physiognomy. About the last mentioned era, however, and from thence to the decline of the empire under the later emperors, the science appears to have been cultivated as an important branch of erudition, and assumed as a profession by persons who had acquired a superior knowledge in it.

In the works of Hippocrates and Galen, many physiognomical observations occur. Cicero appears to have been peculiarly attached to the science. In his oration

tion againſt Piſo, and in that in favour of Roſcius, the reader will at the ſame time perceive in what manner the orator employs phyſiognomy to his purpoſes, and find a curious inſtance of the *ancient* manner of oratorical *abuſe*.

Many phyſiognomical remarks are to be found likewiſe in the writings of Salluſt, Suetonius, Seneca, Pliny, Aulus Gellius, Petronius, Plutarch, and others.

That in the Roman empire the ſcience was practiſed as a profeſſion, ample evidence appears in the writings of ſeveral of the authors juſt mentioned. Suetonius, for inſtance, in his *Life of Titus*, mentions that Narciſſus employed a *phyſiognomiſt* to examine the features of Britannicus, who predicted that Britannicus would not ſucceed, but that the empire would devolve on Titus.

9 This ſcience fell with the Roman empire.

The ſcience of phyſiognomy ſhared the ſame fate with all others, when the Roman empire was overthrown by the northern barbarians. About the beginning of the 16th century it began again to be noticed.—From that time till the cloſe of the 17th, it was one of the moſt faſhionable ſtudies. Within that ſpace have appeared almoſt all the approved modern authors on the ſubject (B).

It has been unfortunate for phyſiognomy, that by many of theſe writers it was held to be connected with doctrines of which the philoſophy of the preſent day would be aſhamed. With theſe doctrines it had almoſt ſunk into oblivion.

10 Particular ſtudies have peculiarly prevailed at particular times.

In every period of the hiſtory of literature there may eaſily be marked a prevalence of particular ſtudies. In the early period, for inſtance, of Grecian literature, *mythological morality* claimed the chief attention of the philoſophers. In the more advanced ſtate of learning in Greece and in Rome, *poetry*, *hiſtory*, and *oratory*, held the pre-eminence. Under the latter emperors, and for ſome time afterwards, the hiſtory of *theological controverſies* occupied the greateſt part of works of the learned. Next ſucceeded *metaphyſics*, and *metaphyſical theology*. Theſe gave place to *alchemy*, *magic*, *judicial aſtrology*, the doctrine of ſignatures and ſympathies, the *myſtic*, *theoſophic*, *and Roſicrucian theology*, with phyſiognomy. Such were the purſuits contemporary with the ſcience which is the object of our preſent inquiry. It is no matter of ſurpriſe, that, ſo aſſociated, it ſhould have fallen into contempt. It is not unuſual for mankind haſtily to reject valuable opinions, when accidentally or artificially connected with others which are abſurd and untenable. Of the truth of this remark, the hiſtory of theology, and the preſent tone of theological opinions in Europe, furniſh a pregnant example.

To phyſiognomy, and the exploded ſciences laſt mentioned, ſucceeded *claſſic philology*; which gave place to *modern poetry* and *natural philoſophy*; to which recently have been added the ſtudies of *rational theology*, *chemiſtry*, the *philoſophy of hiſtory*, the *hiſtory of man*, and the *ſcience of politics*.

11 The obſervations of the writers of the preſent century on this ſubject.

About the commencement of the 18th century, and thence forward, the occult ſciences, as they are termed, had declined very conſiderably in the eſtimation of the learned; and thoſe who treated of phyſiognomy forbore to diſgrace it by a connection with thoſe branches of ideal learning with which formerly it had been invariably conjoined. In Britain, Dr Gwither noticed it with approbation.—His remarks are publiſhed in the Philoſophical Tranſactions, vol. xviii.; and Dr Parſons choſe it for the ſubject of the Croonean lectures, publiſhed at firſt in the ſecond ſupplement to the 44th volume of the Philoſophical Tranſactions, and afterwards (1747) in a ſeparate treatiſe, entitled *Human Phyſiognomy explained*.

The obſervations, however, of theſe writers, as well as of Lancifius, Haller, and Buffon, relate rather to the tranſient expreſſion of the paſſions than to the permanent features of the face and body. The well-known characters of Le Brun likewiſe are illuſtrative of the tranſient phyſiognomy, or (as it is termed) pathognomy.—See *PASSIONS in Painting*.

12 We find nothing very important till the controverſy between Pernetty and Le Cat.

During the preſent century, although phyſiognomy has been now and then attended to, nothing of importance appeared on the ſubject till the diſcuſſion already mentioned between Pernetty and Le Cat, in the Berlin Tranſactions. The ſentiments of theſe authors, in ſo far as relates to the *definition* of phyſiognomy, have been above noticed. Their eſſays are, beſides, employed in diſcuſſing the following queſtions: 1ſt, Whether it would or would not be advantageous to ſociety, were the character, diſpoſition, and abilities, of each individual ſo marked in his appearance as to be diſcovered with certainty?

2dly, Whether, on the ſuppoſition that by the higheſt poſſible proficiency in phyſiognomy, we could attain a knowledge in part only of the internal character, it would be advantageous to ſociety to cultivate the ſtudy, mankind being in general imperfect phyſiognomiſts?

No reaſoning *à priori* can poſſibly determine theſe queſtions. Time and experience alone muſt aſcertain the degree of influence which any particular acquiſition of knowledge would have on the manners and characters of mankind; but it is difficult to conceive how the *reſult* of any portion of knowledge, formerly unknown, and which mankind would be *permitted* to diſcover, could be any thing but beneficial.

13 Lavater's celebrated Work.

Soon after this controverſy in the Berlin Tranſactions, appeared the great work of M. Lavater, dean of Zurich, which has excited no inconſiderable portion of attention in the literary world. The work itſelf is magnificent: That circumſtance, as well as the nature of the ſubject, which was ſuppoſed to be fanciful, have contributed to extend

(B) They are, Bartholem. Cocles, Baptiſta Porta, Honoratus Nuquetius, Jacobus de Indagine, Alſtedius, Michael Schottus, Gaſpar Schottus, Cardan, Taiſnierus, Fludd, Behmen, Barclay, Claromontius, Conringius, the commentaries of Auguſtin Niphus, and Camillus Balbus on the Phyſiognomica of Ariſtotle,—Spontanus, Andreas Henricus, Joannes Digander, Rud. Goclenius, Alex. Achillinus, Joh. Prætorius, Jo. Belot, Guliel. Gratalorus, &c. They are noticed in the Polyhiſtor of Morhoff, vol. i. lib. i. cap. 15. § 4. and vol. ii. lib. iii. cap. 1. § 4.

extend its fame; and certainly, if we may judge, the book, though many faults may be detected in it, is the most important of any that has appeared on the subject since the days of Aristotle. Lavater professes not to give a complete synthetical treatise on physiognomy, but, aware that the science is yet in its infancy, he exhibits fragments only, illustrative of its different parts. His performance is no doubt desultory and unconnected. It contains, however, many particulars much superior to any thing that had ever before appeared on the subject.

With the scholastic and systematic method adopted by the physiognomists of the last and preceding centuries, Lavater has rejected their manner of writing, which was dry, concise, indeterminate, and general: His remarks, on the contrary, are, for the most part, precise and particular, frequently founded on distinctions extremely acute. He has omitted entirely (as was to be expected from a writer of the present day) the astrological reveries, and such like, which deform the writings of former physiognomists; and he has with much propriety deduced his physiognomical observations but seldom from anatomical or physiological reasoning. Such reasoning may perhaps at some future period become important; but at present our knowledge of facts, although extensive, is not so universal, as to become the stable foundation of particular deductions. Lavater has illustrated his remarks by engravings; a method first adopted by Baptista Porta.—Lavater's engravings are very numerous, often expressive, and tolerably executed.

14 His opinions the result of observation.

The opinions of this celebrated physiognomist are evidently the result of actual observation. He appears indeed to have made the science his peculiar study, and the grand pursuit of his life. His performance exhibits an extended comprehension of the subject, by a particular attention to *osseal* physiognomy, and the effect of *profiles* and *contours*. His style in general is forcible and lively, although somewhat declamatory and digressive. His expressions are frequently precise, and strikingly characteristic; and the spirit of piety and benevolence which pervade the whole performance render it highly interesting.

15 His imagination has, however, often outstript his judgement.

The defects of the work, however, detract much from the weight which Lavater's opinions might otherwise challenge. His imagination has frequently so far outstript his judgement, that an ordinary reader would often be apt to reject the whole system as the extravagant reverie of an ingenious theorist. He has clothed his favourite science in that affected mysterious air of importance, which was so usual with his predecessors, and describes the whole material world to be objects of the universal dominion of physiognomy *. He whimsically conceives it necessary for a physiognomist to be a well-shaped handsome man †. He employs a language which is often much too peremptory and decisive, disproportioned to the real substance of his remarks, or to the occasion of making them. The remarks themselves are frequently opposite in appearance to common observation, and yet unsupported by any illustrations of his.

* Vol. i. p. 33.—38. vol. ii. p. 89. French translation.
† Vol. i. p. 106.

16 Other weaknesses of this great physiognomist.

Lavater certainly errs in placing too great a reliance on single features, as the foundation of decision on character. His opinions on the physiognomy of the ears, hands, nails, and feet of the human species, on hand-writing, on the physiognomy of birds, insects, reptiles, and fishes, are obviously premature, as hitherto no sufficient number of accurate observations have been made, in regard to either of these particulars, to authorise any conclusion. He has erred in the opposite extreme, when treating of the important topic of national physiognomy, where he has by no means prosecuted the subject so far as facts might have warranted. We must farther take the liberty to object to the frequent introduction of the author's own physiognomy throughout the course of his work. His singular remarks on his own face do not serve to prejudice the reader in favour of his judgement, however much his character may justify the truth of them. We must regret likewise, for the credit of the science, that the author's singularly fanciful theory of apparitions should so nearly resemble a revival of the antiquated opinions of the sympathists.

To these blemishes, which we have reluctantly enumerated, perhaps may be added that high impassioned tone of enthusiasm in favour of his science everywhere displayed throughout the work of this author, which is certainly very opposite to the cool patient investigation befitting philosophy. To that enthusiasm, however, it is probable that in this instance (as is, indeed, no unfrequent effect of enthusiasm) we are indebted for the excellency which the author has attained in his pursuit; and it possesses the salutary tendency of putting us on our guard against a too implicit acquiescence in his physiognomical decisions.

In the Berlin Transactions for 1775, there appears a formal attack upon Lavater's work by M. Formey. This essay we have already mentioned. After disputing the propriety of the extensive signification applied by Lavater and Pernetty to the term physiognomy, M. Formey adopts nearly the same definition which we conceive to be the most proper, and which we have put down as such near the beginning of this article. He allows that the mental character is intimately connected with, and sensibly influenced by, every fibre of the body; but his principal argument against physiognomy is, that the human frame is liable to innumerable accidents, by which it may be changed in its external appearance, without any correspondent change of the disposition; so that it surpasses the extent of the skill of mortals to distinguish the modifications of feature that are natural, from those which may be accidental. Although, therefore, the science of physiognomy may be founded in truth, he infers that the Deity only can exercise it. 17. His work was attacked in the Berlin Transactions by M. Formey.

M. Formey further contends, that education, diet, climate, and sudden emotions, nay even the temperaments of ancestors, affect the cast of human features; so that the influence of mental character on these features may be so involved with, or hidden by, accidental circumstances, that the study of physiognomy must ever be attended by hopeless uncertainty. These objections are worthy of notice, but they are by no means conclusive.

We shall give a specimen of M. Lavater's manner of treating the subject on the opposite side of the question: A specimen, not in Lavater's precise words, but conveying more shortly an idea at once of his sentiments, and of his manner of expressing them. 18 Lavater's mode of treating his subject.

No study, says he, excepting mathematics, more justly deserves to be termed *a science* than physiognomy. It is a department of physics, including theology and belles lettres, and in the same manner with these sciences may 19 Physiognomy is justly called a science.

may be reduced to rule. It may acquire a fixed and appropriate character: It may be communicated and taught.

Truth or knowledge, explained by fixed principles, becomes ſcience. Words, lines, rules, definitions, are the medium of communication. The queſtion, then, with reſpect to phyſiognomy, will thus be fairly ſtated. Can the ſtriking and marked differences which are viſible between one human face, one human form, and another, be explained, not by obſcure and confuſed conceptions, but by certain characters, ſigns, and expreſſions? Are theſe ſigns capable of communicating the vigour or imbecility, the ſickneſs or health, of the body; the wiſdom, the folly, the magnanimity, the meanneſs, the virtue, or the vice, of the mind?

20 Experiment is limited in extent.

It is only to a certain extent that even the experimental philoſopher can purſue his reſearches. The active and vigorous mind, employed in ſuch ſtudies, will often form conceptions which he ſhall be incapable of expreſſing in words, ſo as to communicate his ideas to the feebler mind, which was itſelf unable to make the diſcovery: But the lofty, the exalted mind, which ſoars beyond all written rule, which poſſeſſes feelings and energies reducible to no law, muſt be pronounced unſcientific.

21 Phyſiognomical truth may be defined and communicated to a certain length.

It will be admitted, then, that to a certain degree phyſiognomical truth may as a ſcience be defined and communicated. Of the truth of the ſcience there cannot exiſt a doubt. Every countenance, every form, every created exiſtence, is individually diſtinct, as well as different, in reſpect of claſs, race, and kind. No one being in nature is preciſely ſimilar to another. This propoſition, in ſo far as regards man, is the foundation-ſtone of phyſiognomy. There may exiſt an intimate analogy, a ſtriking ſimilarity, between two men, who yet being brought together, and accurately compared, will appear to be remarkably different. No two minds perfectly reſemble each other. Now, is it poſſible to doubt that there muſt be a certain native analogy between the external varieties of countenance and form and the internal varieties of the mind? By anger the muſcles are rendered protuberant: Are not, then, the angry mind, and the protuberant muſcles, as cauſe and effect? The man of acute wit has frequently a quick and lively eye. Is it poſſible to reſiſt the concluſion, that between ſuch a mind and ſuch a countenance there is a determinate relation?

Every thing in nature is eſtimated by its phyſiognomy; that is, its external appearance. The trader judges by the colour, the fineneſs, the exterior, the *phyſiognomy* of every article of traffic; and he at once decides that the buyer "has an honeſt look," or "a pleaſing or forbidding countenance."

22 This knowledge, however improved, would not be detrimental to man.

That knowledge and ſcience are detrimental to man, that a ſtate of rudeneſs and ignorance are preferable and productive of more happineſs, are tenets now deſervedly exploded. They do not merit ſerious oppoſition. The extenſion and increaſe of knowledge, then, is an object of importance to man: And what object can be ſo important as the knowledge of man himſelf? If knowledge can influence his happineſs, the knowledge of himſelf muſt influence it the moſt. This uſeful knowledge is the peculiar province of the ſcience of phyſiognomy. To conceive a juſt idea of the advantages of phyſiognomy, let us for a moment ſuppoſe that all phyſiognomical knowledge were totally forgotten among men; what confuſion, what uncertainty, what numberleſs miſtakes, would be the conſequence? Men deſtined to live in ſociety muſt hold mutual intercourſe. The knowledge of man imparts to this intercourſe its ſpirit, its pleaſures, its advantages.

23 It affords great mental gratification.

Phyſiognomy is a ſource of pure and exalted mental gratification. It affords a new view of the perfection of Deity; it diſplays a new ſcene of harmony and beauty in his works; it reveals internal motives, which without it would only have been diſcovered in the world to come. The phyſiognomiſt diſtinguiſhes accurately the permanent from the habitual, the habitual from the accidental, in character. Difficulties, no doubt, attend the ſtudy of this ſcience. The moſt minute ſhades, ſcarcely diſcernible to the unexperienced eye, denote often total oppoſition of character. A ſmall inflexion, diminution, lengthening or ſharpening, even though but of a hair's-breadth, may alter in an aſtoniſhing degree the expreſſion of countenance and character. How difficult then, how impoſſible indeed, muſt this variety of the ſame countenance render preciſion? The ſeat of character is often ſo hidden, ſo maſked, that it can only be detected in certain, perhaps uncommon, poſitions of countenance. Theſe poſitions may be ſo quickly changed, the ſigns may ſo inſtantaneouſly diſappear, and their impreſſion on the mind of the obſerver may be ſo ſlight, or theſe diſtinguiſhing traits themſelves ſo difficult to ſeize, that it ſhall be impoſſible to paint them or deſcribe them in language. Innumerable great and ſmall accidents, whether phyſical or moral, various incidents and paſſions, the diverſity of dreſs, of poſition, of light or ſhade, tend to diſplay the countenance often in ſo diſadvantageous a point of view, that the phyſiognomiſt is betrayed into an erroneous judgement of the true qualities of the countenance and character. Such cauſes often occaſion him to overlook the eſſential traits of character, and to form a deciſion on what is purely accidental.—How ſurpriſingly, for inſtance, may the ſmallpox disfigure the countenance, and deſtroy or confound, or render imperceptible, traits otherwiſe the moſt deciſive?

24 Difficulties in the ſtudy.

25 May one day be obviated.

We ſhall, then, continues Lavater, grant to the oppoſer of phyſiognomy all he can aſk; and yet we do not live without hopes that many of the difficulties ſhall be reſolved which at firſt appeared inexplicable.

26 The nature of Lavater's work.

He then proceeds to a ſpecific illuſtration of his ſubject under a great variety of titles, in which he treats of human nature in general, and of each particular feature ſeparately.

To enumerate the different diviſions of his book would not be more ſatisfactory to our readers than the peruſal of the *contents* of the book itſelf; and an attempt to epitomize even the eſſential ſubſtance of the vaſt multiplicity of matter contained in his eſſays, (which are yet only *fragments*, and to which indeed he himſelf does not pretend to give any higher appellation), would extend this article to a diſproportionate length. Such an abridgement, after all, would convey no ſolid information on a ſubject which merits all the time and ſtudy that an attentive peruſal of Lavater's works at large would require.

27 Probable cauſes of the diſrepute into which this ſcience has fallen.

From the hiſtorical deduction of the literary progreſs of phyſiognomy which we have thus attempted to lay before our readers, it appears, that although the ſcience has fallen into diſrepute, there can ſcarcely be mentioned ed a period in which any cultivation of ſcience took place when phyſiognomy was not likewiſe the ſtudy, nay ſometimes even the profeſſion, of men of the moſt eminent abilities and the greateſt learning.

The reaſons why at preſent ſo little attention is paid to the ſubject probably are,

1ſt, That it has been treated in conjunction with ſubjects now with propriety exploded: And,

2dly, That it has been injured by the injudicious aſſertions and arguments of thoſe who have undertaken its defence.

Sometimes, however, the wiſe and the learned may err. The uſe of any thing muſt not be rejected for no better reaſon than that it is capable of abuſe. Perhaps the era is not diſtant when phyſiognomy ſhall be reinſtated in the rank which ſhe merits among the valuable branches of human knowledge, and be ſtudied with that degree of attention and perſeverance which a ſubject deſerves ſo eſſentially connected with the ſcience of man.

28 There is a relation between the diſpoſitions of the mind and the features of the face.

That there is an intimate relation between the diſpoſitions of the mind and the features of the countenance is a fact which cannot be queſtioned. He who is ſinking under a load of grief for the death of an affectionate wife or a dutiful child, has a very different caſt of features from the man who is happy in the proſpect of meeting his miſtreſs. A perſon boiling with anger has a threatening air in his countenance, which the moſt heedleſs obſerver never miſtakes; and if any particular diſpoſition be indulged till it become habitual, there cannot be a doubt but that the correſponding traces will be ſo fixed in the face as to be diſcernible by the ſkilful phyſiognomiſt, under every effort made to diſguiſe them. But when we attempt to decide on a man's intellectual powers by the rules of this ſcience, we are often deceived; and in this reſpect we have reaſon to believe that Lavater himſelf has fallen into the groſſeſt miſtakes.

29 Craniognomic ſyſtem of Dr Gall.

Connected with phyſiognomy, we may conſider the *craniognomic* ſyſtem of Dr Gall of Vienna, which is ſo called, becauſe, from the exterior form of the cranium, he infers the powers and diſpoſitions of the mind. The brain, he obſerves, is the material organ of the action of the mind; and as it increaſes in direct proportion to the faculties of animals, he has endeavoured to prove, that the faculties are diſtinct and independent on each other; that each has its proper material organ, and that the expanſion of the organ is in proportion to the ſtrength of the faculty. This ſyſtem is attempted to be eſtabliſhed by the following reaſoning.

"The internal faculties, (ſays Dr Bojanus, the author of a view of this ſyſtem), do not always exiſt in the ſame proportion to each other. There are ſome men who have a great deal of genius without having a memory, who have courage without circumſpection, and who poſſeſs a metaphyſical ſpirit without being good obſervers.

"Beſides, the phenomena of dreaming, of ſomnambuliſm, of delirium, &c. prove to us that the internal faculties do not always act together; that there is often a very great activity of one, while the reſt are not ſenſible.

"Thus, in old age, and ſometimes in diſeaſe, ſuch, for example as madneſs, ſeveral faculties are loſt, while others ſubſiſt; beſides, a continued employment of the ſame faculty ſenſibly diminiſhes its energy: If we employ another, we find it has all the force of which it is ſuſceptible; and if we return to the former faculty, it is obſerved that it has reſumed its uſual vigour. It is thus that, when fatigued with reading an abſtract philoſophical work, we proceed with pleaſure to a poetical one, and then reſume with the ſame attention our former occupation."

"All theſe phenomena prove that the faculties are diſtinct and independent of each other, and we are inclined to believe that the caſe is the ſame with their material organs."

"[We do not entirely agree with this idea of Dr Gall, and we believe, on the contrary, that the ſeparation of the material organs ought to be conſidered as the cauſe of the diſtinction of the internal faculties. It appears, to us at leaſt, that by ſuppoſing the faculties themſelves as originally ſeparated, we cannot ſave ourſelves from falling into materialiſm, which exiſts when the mind is no longer conſidered as unity.]

"*The expanſion of the organs contained in the cranium is in the direct ratio of the force of their correſponding faculties.*"

"This principle, dictated by analogy, reſts on this axiom, that throughout all nature the faculties are always found to be proportioned to their relative organs; and the truth of it is proved in a ſpecial manner by the particular obſervations of Dr Gall.

"It is however to be remarked, that exerciſe has a great influence on the force of the faculties, and that an organ moderately expanded, but often exerciſed, can give a faculty ſuperior to that which accompanies a very extenſive organ never put in action; as we ſee that a man of a weak conformation acquires, by continued exerciſe, ſtrength ſuperior to another of a more athletic ſtructure."

"[We muſt here mention an opinion which ſeems to reſult immediately from this principle, and which, however, is falſe: It is, that the volume of the brain, in general, is in the direct ratio of the energy of its faculties. Obſervation has proved to Dr Gall, that we cannot judge of the ſtrength of the faculties but by the developement of the ſeparate organs which form diſtinct eminences in the cranium; and that a cranium perfectly round, of whatever ſize it may be, is never a proof of many or of great faculties.]

"We do not recollect to have heard the reaſon aſſigned by Dr Gall; but, in our opinion, theſe brains may be conſidered as in a ſtate analogous to obeſity; and as we do not judge of the muſcular force of a man or an animal by the volume of their members, but by the developement of the muſcles in particular, one would think we ought, in like manner, to judge of the ſtrength of the faculties by the developement of the relative organs.

"In the laſt place, the 4th principle, the moſt important for practice in regard to the ſyſtem of Dr Gall, is:

"*We may judge of theſe different organs and of their faculties by the exterior form of the cranium.*

"The truth of this principle is founded upon another, viz. that the conformation of the cranium depends on that of the brain; a truth generally acknowledged, and proved by the anterior part of the brain, by the impreſſions in the anterior part of the cranium, and by other facts.

[There are ſkulls, it is true, in which an external protuberance

protuberance of the bone corresponds to an interior one; and this irregularity, which is found sometimes as a disease, and most commonly at an advanced age, when the cerebral organs do not oppose the same resistance to the cranium, renders the practice of Dr Gall's system, in some measure, uncertain.]

"Guided by these principles, Dr Gall examines the nature of the skull, compares the crania of animals and those of men analogous and different in faculties. His researches have proved to him, in a manner almost incontestable, not only the above truths, but that the faculties of animals are analogous to those of man; that what we call instinct in animals is found also in the latter, such as attachment, cunning, circumspection, courage, &c.; that the quantity of the organs fixes the difference of the genus of animals, their reciprocal proportion that of individuals; that the disposition originally given to each faculty by nature may be called forth by exercise and favourable circumstances, and sometimes by disease, but that it never can be created in the case where it has not been given by nature (c); that the accumulation of the organs takes place in a constant manner from the hind part forwards, from the bottom to the top, in such a manner, that animals in proportion as they approach man in the quantity of their faculties have the superior and anterior part of the brain more expanded; and, in the last place, that in the most perfect animal, man, there are organs in the anterior and superior parts of the frontal bone, and of the parietals, destined for faculties which belong to them exclusively. It is under the latter point of view that the discoveries of Dr Gall agree perfectly with the theory of the facial angle, which seems still further to establish the truth of them."

Most of our readers will probably be satisfied with the short view which we have now given of this fanciful and visionary system; but such as wish for a fuller exposition of it, may consult the Philosophical Magazine, vol. xiv. p. 77. from which the above is extracted. We shall only add the names of a few of the organs, which the author of the system thinks he has discovered. *Organ of the tenacity of life. Organ of music. Organ of fighting. Organ of murder. Organ of cunning. Organ of arithmetic. Organ of thieving, &c.*

(c) The germ of every organ must exist in embryo, if the expansion of that organ is to be afterwards called forth.

PHYSIOLOGY.

INTRODUCTION.

1 Definition and objects of physiology.

1. PHYSIOLOGY is that part of physical science which treats of the nature, properties, and functions of living bodies; comprehending under this term, animals and vegetables. The word is derived from φυσις, "nature," and λογος, "a discourse;" and signified originally what we may call *natural knowledge.*

The object of this science is to examine and compare the phenomena of life; to discover the properties, powers, and operations of the bodies that are actuated by this principle, and to pursue the developement, progress, and decay of vital energy, from brute matter, which possesses no portion of vitality, to the most perfect animal, which seems to have it in the greatest perfection.

2 Divisions.

2. Physiology may be considered under three heads; *historical*, *philosophical* or *rational*, and *practical* physiology.

3 Historical physiology.

3. *Historical physiology* is occupied in giving a simple relation of the facts and phenomena that take place in living bodies; in bringing them together, and comparing those which succeed each other without interruption during the existence of vitality.

4 Philosophical physiology.

4. It is the business of *philosophical physiology* to consider the nature of these phenomena, and endeavour to deduce from them some general conclusions, by which they may be explained or elucidated; to draw from them natural consequences, and unfold successively their analogies and relations; to arrange, distribute, and classify them, and thus acquire sufficient *data* by which to discover the causes which produce them.

5 Practical physiology.

The *practical* part of physiology is intended to point out the application of the principles of the science to the useful purposes of life, especially to medicine and agriculture. Of these divisions the first is the most important, as, until we have acquired a pretty complete knowledge of the facts relating to living beings, and arranged these in a natural manner, it cannot be expected that we should make any great progress in explaining them, or investigating their causes. From the multitude, variety, and complex nature of these phenomena, a complete view of them is extremely difficult, and requires the united efforts of genius, dexterity, patience, and discernment.

6 Relations to anatomy,

Physiology is intimately related to several other departments of natural knowledge. Its relation to anatomy is the most strict and natural; and indeed the knowledge of the structure of living bodies is a necessary introduction to that of their properties and functions. So close is the union between these two sciences, that it is generally thought that the study of them should go hand in hand. Certain it is, that, without physiology, anatomy is a dry and uninteresting study; while, on the other hand, physiology, unaided by anatomy, is obscure and uncertain. It is by means of anatomy that we learn the structure and organization of the animal machine; the disposition and form of its several members; the parts that concur in the composition of them; the arrangement and the connection of these: it is by means of anatomy that we know how to estimate the advantages

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ges of any particular conformation; that we eſtimate the proportion between the ſolid and fluid parts of the body, and the adaptation of the organs to the various uſes for which they are deſtined. But we muſt remember, that the aid of anatomy in phyſiological reſearches, extends no farther than to the mechanical arrangement and relation of the ſeveral parts of the body; it teaches us nothing of its intimate compoſition, and much leſs does it inform us reſpecting the vital powers and mental energies diſplayed by the living body. The moſt accurate inſpection of the brain will afford us no light reſpecting the obſcure function of ſenſation, and the hidden operation of thought and judgement; nor will the niceſt diſſection of the eye, or of the tongue, ſhew us how the former is enabled to convey to us the ideas of external objects, or how the latter imparts to us the thouſand varied flavours of ſapid bodies. In ſhort, we may conclude, that the more the exerciſe of any function depends on the ſtructure and organization of the organs that perform it, the more capable is it of illuſtration from anatomy.

7 chemiſtry,

The ſcience of chemiſtry has proved of eminent uſe in explaining ſeveral functions of the animal economy, which, without its aſſiſtance, would have been very imperfectly underſtood. The action of the air on the blood during reſpiration, and the digeſtion of food in the ſtomach, are found to depend chiefly on chemical operations; while this ſcience has explained to us, in a moſt ſatisfactory manner, the nature, compoſition, and reciprocal action of the component principles of organized beings, and the nature of ſeveral changes which they undergo, both in the living and the dead ſtate. But if we extend the application of chemiſtry too far, and imagine, as ſome of our modern chemical phyſiologiſts have done, that it is capable of explaining *life*, *motion*, and even *ſenſation*, we ſhall only betray our own preſumption and our ignorance of vital phenomena. When the performance of any function depends on the intimate compoſition of its organs, or the combinations and decompoſitions that take place among their component principles; then, and then only, is it ſuſceptible of chemical illuſtration.

8 mechanical philoſophy,

Mechanical philoſophy is employed with advantage in explaining ſome of the phenomena that take place in living beings. The ſtrength and ſolidity of the bony compages; the force and direction of the muſcular motions; the propagation, direction, and mechanical effect of light, ſound, odours; the effects of the gravity and elaſticity of atmoſpheric air, and a few other circumſtances, may be ſubmitted to calculation, and illuſtrated on phyſical principles: but the laws of mechanical and of vital action are, in general, ſo different, and even the moſt mechanical phenomena of living beings are often ſo modified and counteracted by the agency of the vital powers, that, on the whole, we muſt conſider general phyſics as one of the leaſt uſeful auxiliaries of phyſiological reſearches.

9 metaphyſics,

Of all the branches of phyſical ſcience, phyſiology certainly makes the neareſt approach to the region of metaphyſics; but yet there is a difference between theſe, though it may not be very eaſy to point out the preciſe line of termination. Phyſiology, as already defined, being that ſcience which has for its object the organical economy of living bodies, the word organical, we think, here ſhould mark the diſtinction.

Whenever the economy of living bodies indicates deſign, and cannot reſult from any combination or ſtructure of organs, it muſt be ſuppoſed the effect of ſomething different from matter, and whoſe explanation belongs to that ſcience which is called *metaphyſics*, or which we might term the *philoſophy of the mind*. By aſcribing, indeed, to the glandular contents within the cranium, and to that fiction animal ſpirits, the motives of action, the ſuperficial and ill-informed may have been led to an opinion that perception, memory, and imagination, are the functions of the *cerebrum*, the *medulla oblongata*, and *cerebellum*; that the ſoul is a conſequence of organization; and the ſcience which treats of it only a particular branch of phyſiology. But mind and its faculties are now ſo well underſtood and inveſtigated, that this opinion can ſeldom prevail but where penetration is not remarkable for its acuteneſs, or where reflection, reading, and reſearch, have long been confined within the limits of a narrow circle.

Some metaphyſical phyſiologiſts contend, that every living ſyſtem of organs ſuppoſes mind, and indeed in the ſtudy of ſuch ſyſtems the phyſiologiſt muſt often meet with many phenomena that are leſs ſingular than ſimple perception, and yet for which he cannot account by any knowledge he poſſeſſes of organic powers. This truth we partly acknowledge, when, like ancient Athens erecting her altars to unknown gods, we retreat to thoſe aſylums of ignorance, the *vis inſita*, the *vis nervea*, the *vis vitalis*, the *vis medicatrix*, and a number of others of the ſame kind.

Phyſiology, in the general ſenſe in which we have defined it, is a ſcience that inveſtigates the nature and the functions of all living beings. It is, therefore, reaſonable to ſuppoſe that it muſt have an intimate connection with natural hiſtory, and in fact, it is to this branch of phyſics that it has been perhaps more indebted than to any other. A comparative view of the various gradations among organized beings has taught us to appreciate the value of the ſeveral functions that characteriſe vitality, and has ſhewn us, that in proportion as the ſtructure is more complex, the functions are more numerous, and more complete. Repeated obſervations, and multiplied experiments on various tribes of animated nature have cleared up many doubtful and obſcure phenomena in the economy of man, and a continuation of this truly philoſophical method of reſearch promiſes to place phyſiology on the ſolid baſis of experience, and enable us to reaſon, where only we can reaſon with ſafety, by a deduction from facts. The more numerous theſe facts, and the more complete their arrangement, the more extenſive, and the more ſecure will be the foundation which they afford for phyſiological concluſions. In ſhort (to uſe the language of Dumas, who has illuſtrated this relation at great length), "the phyſiologiſt who is converſant with natural hiſtory, is ſo much the better fortified againſt uncertain opinions inaſmuch as he has more fully obſerved the operations of nature in connection and in detail. An hypotheſis which to others appears perfectly adequate to the object in view, is not convincing to him. He riſes above the particular object to which it is accommodated, in order to appreciate its value; and it is often among circumſtances which are foreign to the original ſubject, that he ſeeks for exceptions or contradictions that overturn the hypotheſis. Every thing that may ſerve to complete the knowledge

10 and natural hiſtory.

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knowledge of the animal economy enters into his plan; and as the nature of man is so much the less incomprehensible as we employ a greater number of comparative ideas in its exposition, it is doubtless in the power of natural history to elucidate that subject, by revealing a multitude of unknown relations between man and those beings which resemble or which differ from him.*"

* *Dumas Principes de Physiologie*, tom. i. p. 231.

11 Importance and utility of physiology.

The importance and utility of physiology will scarcely be questioned, and need therefore but little illustration. To all who desire to become acquainted with the operations that take place in the animal economy, or to trace the progress of vegetation, and examine the various changes produced on the seed or bud from the action of air, heat, and moisture, (and what studies can be more deserving of a rational and an enlightened mind?) physiology must afford the most interesting subjects of contemplation. To the anatomist and the botanist, it relieves the tedium of dry description and severe classification; to the physician it holds out the surest lights to direct his researches into the circumstances that are favourable to life and health, into the nature and phenomena of death, and of course, the means of avoiding or delaying its attack; to the agriculturist it furnishes some of the most certain principles to direct him (with the aid of chemistry) in the choice of soils, and the application of manures; while to the genuine naturalist, no subject presents such a field of amusement and instruction. When it shall have been rendered as complete as the state of contemporary science will allow, it will exhibit the general result of all those experiments and observations that have purposely been made to illustrate the phenomena of animated matter, or have accidentally contributed to that illustration; and when it shall reach that summit of perfection to which the efforts of genius may carry it, it may diffuse a light, of which at the present day we can form no just or adequate conception. On many occasions it may introduce order for confusion, certainty for doubt; and may establish science, in various departments that are now occupied by fancy and conjecture.

After having pointed out the *nature*, *divisions*, *relations*, and *utility* of physiology, it may not be improper to make a few remarks on the best methods of pursuing the study of it, and the works that are most worthy of a perusal.

12 Methods of studying physiology.

From what has been said of the relations between physiology and other sciences, it will be inferred that the student of our present subject should come prepared with a moderate share of knowledge in anatomy, both human and comparative, of chemistry, of mechanical philosophy, especially dynamics, optics, pneumatics, and acoustics; and natural history, especially zoology and botany. At least the *rudiments* of these branches should be well understood, and the student will then have laid a foundation on which to raise a firm and durable superstructure.

He has now to make himself acquainted with what is already known; and in this inquiry it is of much consequence that he should select those works that embrace the whole subject, without being too diffuse on the one hand or too brief and general on the other. The *Elementa Physiologiæ* of Haller contains a mass of information that will ever render it valuable as a book of reference, though it will scarcely at the present day be studied as a system of physiology. His *Primæ Lineæ Physiologiæ*, though first written, is chiefly a compendium of the larger work, and is better adapted to the general student, though, from its not containing the later discoveries in the science, it is far from complete. The *Institutiones Physiologiæ* of Blumenbach is a useful work, though it has now given place to the later and more accurate publications of Cuvier and Dumas. The *Anatomie Comparée* of the former writer contains an excellent digest of comparative physiology, and the preliminary observations prefixed to the anatomical details contained in this work, may be read with considerable advantage. Probably, however, the *Principes de Physiologie* of Dumas is the most perfect and scientific modern production that has appeared on the subject. We cannot say so much of the *Elements of Physiology* lately published by Richerand, and translated into English by Mr Kerrison; for although it contains considerable information, and a great display of reading, and even of original observation and experiment, it is neither scientific nor always very accurate. The works of Bichat, especially his *Anatomie Generale*, *Anatomie Descriptive*, and his *Recherches Physiologiques sur la Vie et la Mort*, abound with excellent physiological remarks, and, allowing for the great extent to which he has carried some peculiar doctrines, are among the best that have appeared on the animal economy.

In our own country, we have many valuable treatises and papers on different parts of physiology, and the names of Hunter, Monro, Home, Cooper, Abernethy, Carlisle, Sanders, Barclay, Jones, and many others, will ever reflect honour on the country and on the age in which they lived. We can scarcely, however, point out a complete work in our language on the general subject of physiology, though we doubt not that many will be disposed to consider the *Zoonomia* of Dr Darwin as entitled to that appellation. We allow that this is a stupendous monument of the genius and industry of its author, and it contains an ample store of valuable facts, which, if they could be divested of the hypothesis with which they are so much blended, would be extremely useful to the cause of physiological science. At present many of them tend to mislead, by a shew of metaphysical acuteness, and by the new sense in which several terms are employed. Another of Dr Darwin's works, not less valuable, in a physiological point of view, is his *Phytologia*, in which he treats of the economy of vegetation with ability and success.

13 Means of advancing and improving physiology.

He who is desirous of advancing and improving the science of physiology, must, in the first place, have recourse to a patient, and, as far as may be, an accurate observation of the phenomena that take place in organized beings; but the multitude, the variety, and complicated nature of these phenomena, place in his way obstacles that it is difficult to surmount. It is only through time, and patience, and assiduity, that he can attain his object; and it requires considerable dexterity and acuteness to detect the appearances under which these phenomena sometimes present themselves, to pierce through the obscurity in which they are often involved, and to avoid, in a route so uncertain, both the illusions of sense and the errors of genius. The living body has properties peculiar to itself, while it also possesses others that are common to it with brute matter. The phenomena by which it manifests these two orders of properties, are therefore of two kinds, as they relate particularly

Introduction. larly to the state of vitality, and as they are found in every object that exists. These latter are subject to the general laws of matter, are confounded with the phenomena of universal nature, and may be denominated *physical phenomena*. Among the former, some are confined to the arrangement or disposition of the parts in organs, and depend on the structure or form of these organs. These may be called *organic phenomena*. Others depend on the particular laws that govern vital beings, and are not the result of any peculiar organization; these are *vital phenomena*.

14 Observation. Observation alone is sufficient to indicate the presence or the existence of these phenomena; but to unveil them fully there is required an unceasing attention, that is resolved to pursue them through the changes produced by age, sex, climate, situation, and all those circumstances that can affect the living system.

15 Experiment. To observation, he must add, wherever this can be done with a chance of accuracy, a patient investigation of nature by experiment. From the experiments of Spallanzani and Stevens on digestion; of Goodwin, Menzies, Spallanzani, and Davy on respiration; of Monro, Galvani, Volta, and a hundred others on animal irritability, with many other experiments made both at home and abroad, more light has been thrown on the economy of living bodies, than by all the hypotheses and theories that the most ingenious speculatists have contrived since the first dawn of infant science.

16 Cautions. In following out Bacon's great plan of observation and experiment, we must, however, take care in physiological, as in all other physical inquiries, not to be too hasty in our conclusions, and not to suppose that we have reached the bottom of the well of truth, when we have barely got within its verge. Further observations on this subject are unnecessary here, as we have already treated it at some length in the articles PHILOSOPHY and PHYSICS.

17 Modern arrangements. We shall conclude these introductory remarks with a brief sketch of the principal arrangements of modern physiologists, and a tabular outline of the subject as we propose to treat it in the following pages.

18 Two modes of arrangement. There are two modes of arrangement that have usually been adopted in treating physiology; one according to the order of the functions, and another according to that of the organs by which these are performed. The latter of these was adopted by Haller; the former is that of Damas, Cuvier, and most of our later physiologists.

19 Arrangement of Dumas. Dumas, after a long introductory discourse, in which he treats of the best method of pursuing the study of anatomy and physiology, divides his subject into six parts. In the first of these he offers some general views respecting anatomy, physiology, and all the branches of physics which are employed in illustrating the nature and properties of organized and living beings. In this part he gives a compendious history of the progressive improvements in anatomy and physiology, points out the relations that take place between these sciences, and the auxiliary branches of mathematics, mechanical philosophy, chemistry, and natural history; he considers the principal differences that distinguish organized from inorganic matter; the nature, effects, and duration of life, and of the general and particular powers or faculties of nature, both in living and brute matter.

In the second part he lays down the fundamental principles on which the physical constitution and particular economy of man depend; treats of man considered individually; of his formation, structure, and varieties; of the modifications produced in the nature of man by age, sex, habit, and temperament: of the relations between man and external objects; of the action and reaction of the organic systems on each other; of the organic structure of man, and of its several varieties in the different parts and organs; of the natural composition of the different fluids and solids of the human body: and gives a methodical division of the functions, with a critical examination of the modes of classification commonly received.

In the third part he treats of the phenomena of the animal economy, in the relation which they bear to the perpetual commerce established between man and the organs that surround him, or of *sensation* and *motion*. Here he considers the action of external objects upon man, whence result the phenomena of sensation, and the action of man on external objects, from which arise the phenomena of motion.

In the fourth part he treats of the phenomena of the animal economy, in the relation which they bear to the consistence of the fluids, the cohesion of its solids, and the temperature of the whole system. Here he considers the mutual action between the vessels and the blood, from which result, both in the solids and fluids, that degree of cohesion and pliability that favours the necessary expansibility of the living body, or the function of circulation; the action of the air, and of caloric, on the solids and fluids, from which results the degree of expansion necessary to life, or the function of respiration.

In the fifth part he treats of the phenomena of the animal economy in the relation which they bear to the healthy and entire state of the material substance and composition of the body. Here he considers the action of alimentary substances on the human body, in repairing its loss, and preserving its substance, from which result the phenomena of digestion, absorption, and nutrition; and of the action of certain organs on the fluids of the body, in separating those which do not serve the purposes of nutrition, from which result the phenomena of secretion and excretion.

In the sixth and last part, he treats of the phenomena of the animal economy in the relation which they bear to the commerce established between the individual and the species. Here he considers the mutual physical action of the two sexes, from which arise the phenomena of generation; and the mutual moral action of several individuals, from which result the phenomena of speech, and mutual intelligence.

From this sketch of the arrangement of Dumas it will be seen, that although he takes a very extensive view of the subject, his observations are chiefly confined to the human body.

Though the lectures of Cuvier do not contain a complete system of physiology, the anatomical matter in them is, however, so much blended with observations on the animal economy, that it will be of importance for the physiological student to be acquainted with his arrangement. 20 Arrangement of Cuvier.

The whole work is divided into 30 lectures: the first of which is occupied with preliminary observations on the animal economy, comprehending a general view of the functions of animal bodies; a general idea of the organs of which the animal body is composed; a view of

Introduction. of the principal differences exhibited by these organs, and of the relations which exist among those variations, together with a division of animals founded on their organization. The second lecture treats of the organs of motion in general; the third, fourth, fifth, and sixth lectures are merely anatomical, exhibiting a comparative view of these organs in the several classes of animals. The seventh lecture is strictly physiological, and treats of the organs of motion considered in the several actions of standing, walking, seizing and climbing, leaping, swimming, and flying.

The eighth, ninth, tenth, eleventh, twelfth, thirteenth, fourteenth, and fifteenth lectures, are occupied in considering the anatomy and physiology of the function of sensation. Of these, part of the ninth treats of the nervous system in general, and of its action; part of the twelfth gives the physiology of vision; part of the thirteenth, that of hearing; part of the fourteenth, that of touch; and part of the fifteenth, that of smell and taste.

The sixteenth, seventeenth, eighteenth, nineteenth, twentieth, and twenty-first lectures treat of the organs and phenomena of digestion, mastication, insalivation, and deglutition. The twenty-second lecture treats of what have been called the assistant chylopoietic viscera, namely, the liver, the pancreas, the spleen, and their offices. The twenty-fourth treats of the organs and phenomena of circulation in general; the twenty-sixth of those of respiration in general; the twenty-eighth of the organs of voice.

The twenty ninth treats of the organs and phenomena of generation, and the thirtieth, of those of excretion, comprehending a general view, both of secretion and excretion.

21 Of Bichat. Subjoined to Bichat's introduction to his *Anatomie Generale*, there is a tabular view of physiology, in which, after some preliminary outline of the general structure of the organs and of the phenomena of vitality, he divides the functions into classes, orders, and genera.

The first class consists of the functions that relate to the individual; the first order of which, comprising the functions of *animal life*, comprehends five genera, viz. *sensations*, *cerebral functions*, *locomotion*, *voice*, and *nervous transmission*, besides *sleep*. The second order of this class contains the functions of *organic life*, and comprehends eight genera, viz. *digestion*, *respiration*, *circulation*, *exhalation*, *absorption*, *secretion*, *nutrition*, and *calorification*.

The second class contains the functions that relate to the species in general, and is divided into three orders. The first of these, comprising the functions peculiar to the male, comprehends only one genus, viz. the *production of the seminal fluid*. The second comprises the functions peculiar to the female, and contains three genera, viz. *menstruation*, *the production of milk*, and *of the female generative fluids*. The third order comprises the functions that relate to the union of the two sexes, and the product of that union; and it comprehends also three genera, viz. *generation*, *gestation*, and *delivery*.

Respecting the peculiar doctrines of this writer we shall speak hereafter.

22 Zoological arrangement. There is still another mode of arranging the phenomena of living bodies, that deserves to be noticed, namely, that in which they are arranged according to the artificial systems of natural history. This mode of arrangement, though of infinite advantage to the zoologist, by shewing him at once the extent of his subject, and giving to his memory a power of recollection which it could not otherwise possess, is yet not such as the physiologist would wish to be observed. Zoological arrangements are useful chiefly as they facilitate the study of the manners, dispositions, and habits of different animals; and all that part of the outward economy which indicates something of the wisdom and design displayed by the Creator, in their structure and adaptation to the modes of life which they are intended to pursue; but they do not sufficiently illustrate the internal structure on which this outward economy depends, nor do they sufficiently explain the more secret functions, which being independent of the will of the creature, only display the power and omniscience of him who made it. This will be readily conceived from considering the difference between zoology and physiology, as we have defined it. Zoology is chiefly led to examine the animal kingdom as it usually presents itself to the eye, including a great variety of objects; physiology examines only that part of the animal economy which is principally made known by anatomy and chemistry. Zoology has been accustomed to divide its kingdom into so many classes or orders of animals; physiology would naturally divide its economy into so many functions. Zoology has usually subdivided its classes by certain obvious external marks, as the teeth and claws; physiology would naturally subdivide its functions by the varieties of those organs which are destined to perform them, as the several kinds of lungs and stomachs. Zoology mentions the functions only in a cursory manner, as forming a part of the history of animals; physiology takes notice of animals, only when they are of use to illustrate the functions. To these differences we may add another; that physiology, in the extended sense which we have given it, goes beyond zoology in comprehending the economy of the vegetable creation. From this comparison it will be admitted, that things which are primary in a zoological method, will often be secondary in a physiological arrangement, and *vice versa*. This is very conspicuously the case in one of the grand divisions of Linnæus, viz. mammalia, where the important secretory organs of the milky fluid are noticed only like the colour of the hair, or the length of the tail, as a good outward mark of distinction, and likewise in the excellent table by D'Aubenton in his introductory view of natural history, in the *Encyclopédie Methodique*, in which the function of digestion is not even mentioned.

It is, however, extremely useful, both to the naturalist and physiologist, that the arrangements of both sciences should be, as far as possible, adapted to each other, by marking the relative importance of the several functions in the various classes of living beings. This has been very ably performed by Vicq d'Azyr, a modification of whose table has been given in the comparative part of our ANATOMY. See Vol. II. p. 280. 23 Utility of the application of physiological to zoological arrangement.

With respect to all physiological arrangements we may observe, that as the phenomena of living beings are so intimately dependent on each other, as to form the links of one continued chain, it is of little consequence which of the functions or phenomena we make the point from which we set out in our examination. But as the organs of sensation in most animals, and those of digestion in almost all living creatures, are among the first that 24

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that are evolved, it appears most convenient to begin with one of these. The following is the arrangement that we shall adopt in the present article.

25 Arrangement of the present article.

After giving a sketch of the progress of physiological discoveries and opinions, we shall divide the remaining part of the article into 16 chapters. In the first of these we shall treat of the characteristic marks, general phenomena, duration, and principle of life. In the second we shall consider the phenomena of sensation, the action of the nervous system, and the external senses of feeling, tasting, smelling, hearing, and sight. In the third and fourth chapters we shall treat of irritability, and the phenomena of motion. In the fifth we shall treat of digestion; in the sixth of absorption; in the seventh of circulation; in the eighth of respiration and voice; and in the ninth of nutrition, as completed by the successive performance of the four preceding functions. In the tenth chapter we shall treat of the phenomena of secretion; and in the eleventh, of those of excretion. In the twelfth we shall consider the various means by which living beings defend themselves from external injury, or the phenomena that attend the evolution and change of the integuments, to which function we shall give the name of *integumation*. In the thirteenth chapter we shall consider the transformations that take place in some tribes of living beings, especially insects and reptiles. In the fourteenth we shall briefly examine the phenomena of reproduction, and the hypotheses to which they have given birth. In the fifteenth we shall consider the nature of sleep, and the phenomena of dreams; and in the sixteenth we shall terminate our inquiries by a few observations on the nature and phenomena of death.

The following table is intended to exhibit an outline of the principal circumstances attending the phenomena of life, in the order in which we have enumerated them.

26 Tabular outline.

1. LIFE—is either
- Universally diffused through the body. *Polypi*, &c.
- Most concentrated in certain organs.
- Continued for only a few hours. *Ephemeræ, and some other insects.*
- ———— about a year. *Annual plants.*
- ———— two years. *Biennial plants.*
- ———— several years. *Perennial plants, and most animals.*
- ———— about a century. *Elephants, pikes*, &c.
- ———— several centuries. *Oaks, chesnuts*, &c.

2. SENSIBILITY—Appears to
- Exist in a very low degree in plants. *Sensitivity.*
- Exists in a greater or less degree in all animals.
- Confined to the senses of feeling and taste. *Most zoophytes.*
- Extended besides these to the senses of smelling, sight, and hearing.
- Appears farther extended by an additional sense. *Bats.*

3. IRRITABILITY—Affected by
- Stimulants invisible.
- ———— unknown.
- ———— unthought of.
- The nervous influence.
- Light.
- Heat.
- Moisture.
- Electricity.
- Salts.
- Gases.
- Bodies that act mechanically.

4. MOTION—Performed by
- Legs.
- Wings.
- Fins.
- The tail.
- Organs which fall not properly under these descriptions, *bats, flying opossums*, &c.
- The springiness of the body or of some part of it, *maggots, fleas*, &c.
- Contrivances which fit living bodies for being moved by foreign agents.

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5. Digestion— Performed by an alimentary canal.

- Without teeth.
- With teeth in the mouth.
- ——— in the ſtomach.
- —— ſtones or artificial teeth in the ſtomach.
- —— glands in the mouth for ſecreting a liquor to be mixed with the food.
- —— pouches in the mouth where the food is kept and moiſtened.
- —— a ſac or bag where the food is kept and moiſtened.
- —— a membranous ſtomach.
- —— a muſcular ſtomach.
- —— an intermediate ſtomach.
- Without a cœcum or blind gut.
- With a cœcum.
- —— two cœca.
- —— three cœca.
- —— four cœca.
  - (With a cœcum; two, three, four cœca:) Theſe parts, as well as ruminating ſtomachs and their œſophagus, have antiperiſtaltic motions.
- —— one entrance or mouth.
- —— many entrances by abſorbents.
- Plants have many alimentary canals.
- Some polypes have alimentary canals that branch through the body.
- The alimentary canals of plants and worms diſtribute the fluids without the aid of a circulating ſyſtem.

6. Absorption— Performed by

- Veſſels beginning from the alimentary canal.
- ——————— the cavities.
- ——————— the ſurface.
- Veins in the penis and placenta.
- Re-abſorbents originating from all the parts of the ſyſtem.

7. Circulation— Performed by a ſyſtem with

- One heart.
- A heart for diſtributing the blood through the reſpiratory organs, and an artery for diſtributing it through the ſyſtem.
- One heart for the reſpiratory organs, and one for the ſyſtem, both in one capſule.
- Two hearts for the reſpiratory organs, and one for the ſyſtem.
- A pulmonary heart, or a heart for the reſpiratory organs in the courſe of circulation.
- A pulmonary heart within or without the courſe of circulation at pleaſure.
- A heart ſituated in the breaſt.
- ————— near to the head.
- ————— in the oppoſite extremity.
- Some animals and all plants have no circulating ſyſtem.

8. Respiration— Performed by organs

- Diffuſed through the ſyſtem.
- Confined to one place.
- Situated externally.
- ——— internally.
- In the courſe of the circulation.
- Not in the courſe of the circulation.
- Within or without the courſe of circulation at pleaſure.
- Without tracheæ.
- With tracheæ ramified through the ſyſtem where the reſpiratory organs are generally diffuſed.
- ————— not ramified through the ſyſtem where the reſpiratory organs are confined.
- ————— formed by rings.
- ——————— by ſegments of rings on one ſide, and a membrane on the other.
- ——————— by continuous rings running ſpirally like a ſcrew.
- ————— admitting air by one entrance.
- ————————— by ſeveral entrances.
- ————— wholly concealed in the body.
- ————— partly projecting from the body.
- ——————— opening at the head.
- ————————— at the oppoſite extremity.
- ————————— upon one ſide.
- ——————————— both ſides.

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9. NUTRITION—Food prepared by
- The alimentary canal.
- The lacteals.
- The reſpiratory organs.
- The circulating ſyſtem.
- The cellular membrane.
- The glands.
- And by the ſeveral parts in which it becomes finally aſſimilated.

10. SECRETION—Performed by
- Veſſels.
- Exhaling veſſels.
- Excretory organs.
- Organic pores.
- Glands.
- And by all the parts of which the ſyſtem is compoſed.

11. EXCRETION—Excrementitious matters thrown out by
- The integuments chiefly.
- The common opening of the alimentary canal.
- Two openings of this tube.
- By the lungs and other emunctories.

12. INTEGUMATION—Some living bodies have integuments which are
- Scaly.
- Shelly.
- Membranous.
- Corneous.
- Cretaceous.
- Ligneous.
- Covered with down.
- ———— hair.
- ———— prickles.
- ———— feathers.
- ———— a viſcid matter.
- Change their colour.
- ——— their covering.
- Changed themſelves.

13. TRANSFORMATION—Takes place
- By a change of proportion among the parts.
- ———— of their form.
- — throwing off old parts.
- — an addition of new ones of a different uſe, ſtructure, and form.
- — a change of the whole form together.
- ———— of qualities, propenſities, manners.

14. GENERATION—Performed by
- The temporary union of two ſexes.
- The ſpontaneous ſeparation of parts.
- Organs ſituated in the breaſt.
- ———— in the ſide.
- ———— near to the head.
- ———— in the oppoſite extremity.
- An intrant organ of the male, and a recipient organ of the female.
- An intrant organ of the female, and a recipient organ of the male.
- The ſtamina and piſtils of flowers.
- The ſeminal ſecretion of the male thrown into the organs of the female.
- ———— ſprinkled at the entrance of the female organs.
- ———— thrown upon them from a diſtance.
- ———— tranſported to them by the winds.
- ———— ſprinkled on the embryo after emiſſion.
- ———— diſſolved in a fluid ſecreted by the female before it can rightly perform its office.
- ———— diſſolved perhaps ſometimes in air, as in the caſe of dioicous plants, where it probably acts like an aroma.

15. SLEEP—Natural ſleep is occaſioned by
- Quietneſs.
- The abſence of ſtimuli.
- The ſameneſs of ſtimuli when long continued.
- Deficient aſſimilation.
- Deficient irritability, which is owing ſometimes to the weakneſs, inattention, or confined powers of the mental principle.

16. DEATH. See LIFE.

The

HISTORY.

27 Utility of the hiſtory of phyſiology.

THE early hiſtory of phyſiology can be little more than an account of the opinions of the ancient philoſophers reſpecting the nature and functions of the human body; but as their opinions reflect conſiderable light on the progreſſive improvement of the philoſophy of man, the hiſtory of phyſiology, even in its early ſtages, is curious and intereſting.

28 Opinions of Pythagoras reſpecting man.

Of the origin of phyſiology as a ſcience we know nothing. On examining the writings of the earlieſt philoſophers, we meet with little more than a collection of abſtract principles and hypothetical reaſonings, eſpecially previous to Pythagoras. He conſidered man as a microcoſm, or an epitome of the univerſe, in which were produced the ſame phenomena as in the larger world, only to a leſs extent. He admitted more than one intelligent principle, conducting all the operations of the human body. He ſuppoſed that the human ſoul nouriſhed by the blood, fixed by the veins, the arteries, and the nerves, as ſo many viſible ſituations, became obedient to the general laws of univerſal harmony. He did not pretend that the eternal power of numbers had preſcribed all the phenomena of nature, and that the force of numerical harmonies regulated the motions of the bodies which filled the univerſe, though he has been made ſo to expreſs himſelf by his diſciples. He was contented with aſſerting, that every thing in nature was brought about according to the qualities and proportions of numbers, without attributing to them an intrinſic virtue and a poſitive exiſtence. He perceived that the phenomena of the animal economy ſucceeded each other with a ſtrict regularity, by which they concurred in maintaining order; and in this order he found the principle of the exiſtence and preſervation of all beings; a principle without which they could not exiſt. He conſidered the ſouls of men as emanations from the general ſoul of the univerſe, or *anima mundi.*

29 Of Alcmæon.

Alcmæon conſidered the brain as the ſeat of the ſoul. He ſuppoſed ſound to be produced by the reverberation of the air within the cavity of the ear; and he thought that taſte was owing to the moiſture of the tongue. He compared the body of a fœtus to a ſponge, which obtained its nouriſhment by the ſuction eſtabliſhed over every part of its ſubſtance. According to him, the motion of the blood was the eſſential principle of life; and he ſuppoſed that the ſtagnation of this fluid in the veins produced ſleep, and its active expanſion brought back the waking ſtate of the body. Health conſiſted in the equilibrium and well proportioned mixture of certain primary qualities; and that whenever any of theſe became too predominant, diſeaſe was the conſequence.

30 Of Empedocles and Anaxagoras.

Empedocles involved himſelf in a multitude of abſurd hypotheſes, in order to explain the formation of man, and the combination of the elements from which he was produced. He too, like the diſciples of Pythagoras, ſought among the properties of numbers, for the general principles both of phyſical and moral ſcience. In uniformity with this ſyſtem it was, that he reckoned the four elements, and admitted among the particles of theſe material principles a kind of affection and averſion, of deſire and antipathy, capable of ſeparating and reuniting them, as occaſion might require. He believed that reſpiration commenced within the *uterus*, where the infant was provided from each parent with certain organic particles, which tended to unite into one uniform whole. Anaxagoras, convinced that we muſt attribute the arrangement of matter to the intelligence of a ſuperintending being, imagined that the body of every animal was formed of homogeneous particles, which were brought together by a ſort of affinity. It appeared to him, that bodies which were endowed with thought, were compoſed of ſenſible elements; that theſe elements remained unalterable, and that no power in nature could exert any action on them.

31 Democritus.

Democritus dedicated his life to repeated experiments on plants and animals. He explained the principal phenomena of organized bodies by the action and reaction of atoms, which he ſuppoſed to be endowed with powers eſſentially active, and ſuſceptible of repelling and attracting each other. According to him, generation conſiſted in the coheſion of homogeneous atoms. He conceived the heat inherent in the elements of the body to be the ſole active principle with which man was animated; and that by increaſe of this he became capable of life and motion. He compared the organs of the ſenſes to mirrors, on which were painted the images of things, and he reduced all ſenſations to the ſenſe of feeling, which he ſuppoſed to be more or leſs delicate according to circumſtances.

32 Hippocrates.

Theſe philoſophers, who lived before the time of Hippocrates, had, as we ſee, but very rude and indiſtinct notions of the animal economy; nor were thoſe of the great father of phyſic much ſuperior. Excellent as was his practice, and acute his knowledge of the ſymptoms and progreſs of diſeaſes, the phyſiology of Hippocrates was very lame and defective. He ſeems, indeed, to have underſtood the function of nutrition better than moſt others; he traces the aliment into the ſtomach, ſeems aware of the proceſſes it has to undergo there, and hazards a conjecture that part of the chyle is taken up immediately by the pores of the cellular texture; and that the juices admitted into this membrane, ſerved for the production of milk, the matter of which is afterwards tranſported, and laid up within the breaſts. He attributes to each vital part an attractive force, which it exerts on the nutritious particles, in order to incorporate and appropriate to itſelf thoſe which bear to it a certain analogy. He thought that the heat generated in a living body was kept up entirely by the powers of vitality; and that the external air introduced by reſpiration, ſerved rather to check it, by exerting a cooling effect on the pulmonary organs. He repreſents the human body as agitated in all its parts by an alternate flux and reflux, which carried the matters from within outwards, or brought them from without inwards. From this ſome have ſuppoſed that he underſtood the circulation of the blood, a ſuppoſition made two hundred years ago, and lately again brought forward by the French phyſiologiſts. We ſhall not at preſent ſtay to canvaſs this opinion, which, however, we conceive to be founded on very unſatisfactory arguments.

33 Plato.

After Hippocrates, the ſcience of man was again left to the ſchools of philoſophy, from which he had firſt ſeparated it. Plato is the firſt philoſopher whoſe opinions merit particular notice. He wrote on the phyſiology of man, with his accuſtomed elegance and ſplendor of diction; and he aſſumed the tone of an inſpired prophet in deſcribing, with the force of enthuſiaſm, the grand images that ſuggeſted themſelves to his mind. According

History. cording to him, the human body does not contain within itself the cause of the phenomena which are the consequence or the attendants of life. It is only a passive subject, on which the soul expresses the series of its functions, like the canvas on which the painter traces the conceptions of his inventions. He distinguishes two principles of action in man, a rational soul, on which depend reflection and intelligence, and an irrational soul, on which depend life and motion. The latter is diffused through every part of the body; and it is by means of these parts that it feels, suffers pain, or enjoys pleasure. Thus it is by means of the heart it is susceptible of courage and of passion; by the liver of desire. The head is the seat of reason; the chest, and especially the heart, the seat of strength and anger; the lungs, the general coolers of the body. One division of the irrational soul, which possesses an appetite for food, and all the necessary refreshments of the body, resides in the epigastric region; which, in the language of Plato, is a sort of stable, in which resides a voracious animal. During nutrition, the vital parts assimilate to their substance the aliments which are presented to them; and this assimilation is the consequence of an affinity that takes place between these parts and the nutritious juices. He thus seems to regard nutrition as the effect of a combat between the aliments and the parts of the animal. A young animal will receive more nourishment than one which is old, because the force of its body has more effect in overcoming the force of the nutritious substances.

As the reciprocal action of the soul and the body on each other did not appear to him capable of being explained on the supposition of immateriality, he proposed the idea of a *plastic nature*, which he supposed to be an intermediate principle connecting the soul and the body.

The human body, which is entirely spongy, is exposed through every part to opposite currents of air and fire, which traverse and penetrate it, being introduced alternately by the lungs and by the skin. Hot, cold, dense, rare, and the other sensible properties of bodies, are only the causes of the phenomena which we perceive, and are, as it were, the occasions or accidents that are required to keep in play the intelligent force disseminated through nature.

34 Aristotle. Aristotle, the disciple of Plato, for a long time disputed with him the palm of genius and celebrity; but, as his physiological doctrines differed very little from those of his master, it is unnecessary to detail them, except to remark, that he attributed to the soul three faculties, a *nutritive*, a *sensitive*, and a *rational* faculty; in the first of which life is the only principle; in the second, feeling is produced; and the third is peculiar to man, and is that part of him which knows or judges. This part is either an active or a passive intellect, of which the first may be separated from the body, and is immortal; whereas the second perishes together with the body. Life, according to this philosopher, is a permanence of the soul, retained by the natural heat, the principle of which resides in the heart.

About the period which we are now considering, philosophy was divided into two sects; the materialists, who attributed the formation of all beings to the fortuitous concourse of atoms; and the spiritualists, who held that the soul enjoyed an existence anterior to that of the body, which was no other than a passive organ, in which the phenomena that previously existed in the soul, in an abstract, latent manner, became evident and sensible. To the former sect belonged Democritus and Epicurus; to the latter, Zeno and Plato.

The professors of the Alexandrian school, though they did much for the improvement of anatomy, added little to physiology. Of these Herophilus brought to some degree of perfection the doctrine of the pulse, and seems to have understood the action of the pulmonary organs more correctly than his predecessors, attributing to them a sort of natural appetite, by which they attracted and rejected the matter of respiration. He considered the nerves, the muscles, and the arteries, as the moving powers of the body. 35 Herophilus.

In Galen, also a disciple of this school, we find the most scientific physiologist that has yet come under our notice. He seems first to have ascertained by experiment, that the arteries contain blood, and not air, as had been the opinion of Herophilus and his predecessors; and that they possessed a moving force, independent of that which the heart exercises on the mass of blood, and he found that the contraction of the heart always alternated with a proportional dilatation. He even tried some delicate experiments, in order to ascertain the influence of the nervous system upon the sensitive and motive powers of the body, by which he found, that when a nerve was intercepted with a ligature, the part to which it led became deprived of sense and motion. He believed that the stomach, in a state of contraction, applied itself to the aliment that had been taken in; that the mesenteric veins absorbed a portion of the chyle prepared in the intestines; that the *ductus choledochus* carried the bile from the gall bladder into the duodenum; that the kidneys separated a part of the urine; and he supposed, that another part of this fluid passed immediately from the stomach to the bladder, through some unknown passage. He believed that the lungs transmitted to the blood contained within them, an aerial principle, destined to free them from fuliginous vapours, and to temper the excess of heat generated within the body. The obscure function of generation did not entirely escape his researches; and he made some curious attempts to find out how the sexual organs prepared the seminal fluid, and how this acted in reproduction. 36 Galen.

For more respecting the doctrines of Galen, see the History of MEDICINE.

The commencement of the 13th century is the epoch of a material revolution in physiology. Chemistry having penetrated into Europe, soon exerted its influence on most of the sciences, and especially on those connected with medicine, the doctrines of which were totally changed from their ancient simplicity, and became a farrago of the most wild and fanciful opinions. The Peripatetics and the Galenists sunk into oblivion; and the primitive qualities and occult faculties of the ancient school gave way to the fermentations and effervescences of the chemists. Albertus Magnus and Roger Bacon, when they introduced the science of chemistry, scarcely dreamed of applying it to medicine; but Arnoldus de Villa Nova undertook this application, and sought for the foundation of medical theory amid the processes of his laboratory. Paracelsus followed, and surpassed him in this chemical delirium. An enlightened chemist and a credulous 37 The chemists

History. credulous aſtrologer, his head burning with the fire of his furnaces, and his imagination filled with magical reveries, he believed himſelf capable of conſtructing a new ſyſtem of philoſophy, from examining the courſe of the ſtars, and the products of his alembics. With the daring aſſurance of inſpiration, he declared man to be compoſed of ſulphur, mercury, and ſalt; and, having traced the origin of all diſeaſes to certain chemical operations, he flattered himſelf, that by means of his arcana he could preſerve health, and prolong, to an indefinite extent, the natural duration of human exiſtence.

38 Van Helmont. Van Helmont, the diſciple of Paracelſus, not leſs fanciful, but more ſcientific than his maſter, ſaw the neceſſity of ſomething more than chemical principles to explain the functions of the animal machine. He therefore introduced his *archæus*, an intelligent being, who eſtabliſhed his throne in the epigaſtric region, having ſeveral ſubaltern miniſters under him, who preſided over the ſeveral functions of the body, and whoſe chief ſeats were, the head, the cheſt, and the belly.

39 Des Cartes. In the philoſophy of Des Cartes, the ſeparate exiſtence of the vital principle is entirely rejected. He availed himſelf of the progreſs that had been made by Willis, and ſome other anatomiſts, in the inveſtigation of the nervous ſyſtem, to form an hypotheſis of the vital functions, founded on the ſuppoſition of the nervous fluid, or what was then called the *animal ſpirits;* and this nervous fluid was aſſumed independently of the ſenſitive ſoul, to explain the appearances of ſenſation and voluntary motion.

The diſcovery of the valves in the veins by Fabricius; of the lymphatics by Rudbeck and Bartholin; of the lacteals by Aſellius, and of the circulation of the blood by Harvey, all of which took place during the 17th century, gave to phyſiology an intereſt and a clearneſs which it never poſſeſſed before that period. Some account of the diſcoveries in the circulating and abſorbing ſyſtems, hath been already given under ANATOMY; but as theſe diſcoveries have been productive of great advantages, both in general phyſiology, and in medicine, it will be worth while briefly to trace their origin and progreſs.

40 Diſcovery of the circulation. To begin with the circulation of the blood. Hippocrates ſpeaks of the uſual and conſtant motion of the blood, of the veins and arteries as the fountains of human nature, as the rivers that water the whole body, and which if they be dried up, man dies. He ſays, that the blood-veſſels are, for this reaſon, everywhere diſperſed through the whole body; that they give ſpirits, moiſture, and motion; that they all ſpring from one; and that this one has no beginning and no end, for where there is a circle there is no beginning. In ſuch language was the prince of phyſicians accuſtomed to expreſs his vague ideas of a circulation; for ſo far was he from having acquired accurate conceptions on this ſubject, that when he ſaw the motions of the heart, he believed that the auricles were two bellows to draw in air, and to ventilate the blood.

When after his time anatomy came to be more ſtudied, the notions of the ancients reſpecting the blood were better defined; and, however chimerical they may ſeem to us, they were partly derived from diſſection and experiment. On opening dead bodies, they found that the arteries were almoſt empty, and that very nearly the whole of the blood was collected in the veins, and in the right auricle and ventricle of the heart. They therefore concluded that the right ventricle was a ſort of laboratory; that it attracted the blood from the cavæ; by ſome operation rendered it fit for the purpoſe of nutrition, and then returned it by the way that it came. From the almoſt empty ſtate of the arteries, they were led to ſuppoſe that the right ventricle prepared air, and that this air was conveyed by the arteries to temper the heat of the ſeveral parts to which the branches of the veins were diſtributed. History.

To this laſt notion, entertained by Eraſiſtratus, Galen added an important diſcovery. By certain experiments, he proved, that the arteries contained blood as well as the veins. But this diſcovery was the occaſion of ſome embarraſſment. How was the blood to get from the right to the left ventricle? To ſolve the difficulty in which his new diſcovery had involved him, he ſuppoſed that the branches of the veins and arteries anaſtomoſed; that when the blood was carried to the lungs by the pulmonary vein, it was partly prevented by the valves from returning; that therefore during the contraction of the thorax it paſſed through the ſmall inoſculating branches to the pulmonary vein, and was thence conveyed along with the air to the left ventricle to flow in the aorta. This opinion, ſo agreeable to fact, unfortunately afterwards gave place to another that was the reſult of mere ſpeculation. This notion was, that the left ventricle received air by the pulmonary vein; and that all its blood was derived through pores in the ſeptum of the heart.

The paſſage through the ſeptum being once ſuggeſted, and happening to be more eaſily conceived than one through the lungs, it was generally ſuppoſed the only one for a number of centuries; and ſupported likewiſe, as it was thought, by Galen's authority, it was deemed blaſphemy in the ſchools of medicine to talk of another. In 1543, however, Veſalius having publiſhed his immortal work upon the ſtructure of the human body, and given his reaſons in the ſixth book why he ventured to diſſent from Galen, he particularly ſhewed how it was impoſſible that the blood could paſs through the ſeptum of the heart. His reaſoning rouſed the attention of anatomiſts; and every one grew eager to diſcover the real paſſage which the blood muſt take in going from the right to the left ventricle. The diſcovery of this was firſt made by Michael Servede, a Spaniſh phyſician, who publiſhed his opinion in 1553. He expreſsly ſays, that the blood does not paſs through the ſeptum of the heart, as is commonly believed, but is conveyed by an admirable contrivance from the right ventricle of the heart, by a long paſſage through the lungs. This opinion was deemed heretic, and Servede's book was ſuppreſſed by public authority. Soon after, however, the ſame diſcovery was made by Realdus Columbus, an Italian profeſſor, who publiſhed his account in 1559. It farther appears, that Andreas Cæſalpinus, who publiſhed in 1571, and again in 1593, was acquainted, not only with the leſſer circulation, but obſerved, that the blood ſometimes flowed from the branches of the veins towards their trunks; and that when a vein was tied with a ligature, it ſwelled between the ligature and the diſtant extremity of the vein, and not between the ligature and the heart. He thence inferred, that the veins and arteries opened into each other, and ventured to aſſert

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ſert that the blood could not return by the arteries to the left ventricle of the heart. He did not, however, diſcover the true circulation, but moſt unaccountably maintained with Ariſtotle, of whom he was a zealous diſciple, that the blood flowed like the tides of Euripus, backward and forward in the ſame channel, and ſuppoſed that it flowed from the arteries into the veins during ſleep, and back again from the veins into the arteries till the waking ſtate.

In 1574, Hieronymus Fabricius ab Aquapendente, while he was ſeeking for a cauſe by which to explain the various ſwellings of ſome veins, which had ariſen from friction and ligature, he, to his great joy and aſtoniſhment, diſcovered their valves in one of his diſſections; and here again the true theory of circulation ſeemed almoſt unavoidable. Yet whoever reads the ſmall treatiſe De Venarum Oſtiolis, firſt printed by Fabricius in 1603, will ſoon perceive that he was as far from entertaining a juſt notion of the circulation as his predeceſſors. Notwithſtanding all that he ſaw, he ſtill was of opinion that the blood flowed from the heart to the extremities even in the veins. He thought that the valves were intended by nature only to check and moderate its force. He calls them an inſtance of admirable wiſdom, and miſtakes his own aukward conjecture for one of the deſigns of infinite intelligence. In another reſpect, it muſt be confeſſed that he bore no inconſiderable ſhare in promoting the diſcovery of the circulation. By writing on the valves, the formation of the fœtus, and chick in ovo, he directed the attention of his pupil Harvey to thoſe ſubjects where it was likely that the motion of the blood would frequently occur.

Harvey, who was born in 1578, and graduated at Padua in 1602, examined the valves with more accuracy than Fabricius, and explained their uſe in a treatiſe which he publiſhed ſoon after his graduation. In 1616, he taught the true doctrine of the circulation in his lectures, and publiſhed on the ſubject in 1628. He was the firſt author who ſpoke conſiſtently of the motion of the blood, and who, unbiaſſed by the doctrine of the ancients, drew rational concluſions from his experiments and obſervations. His books preſent us with many indications of a great mind, acute diſcernment, unwearied application, original remark, bold inquiry, and a clear, forcible, and manly reaſoning; and every one who conſiders the ſurpriſe which his doctrine occaſioned among the anatomiſts of thoſe days, the ſtrong oppoſition that it met with from ſome, and the numerous and powerful prejudices which it had to encounter from the ſanction of time and of great names, muſt allow it was new; and that the author has from its importance, a title to rank in the firſt claſs of eminent diſcoverers, ancient or modern.

We have been the more particular in tracing the progreſſive diſcovery of the circulation, and in attempting to ſhew that the real merit of the diſcovery is due to Harvey, becauſe both the abilities and the originality of this eminent man have been called in queſtion by his countryman Dr William Hunter; and many hints are given in the writings of ſome foreign phyſiologiſts, that the circulation was at leaſt gueſſed at by Hippocrates and other ancient writers.

We ſhall be leſs minute in tracing the diſcovery of the lymphatic ſyſtem, becauſe this has been related more at large in the article ANATOMY.

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We learn from Galen, that certain veſſels had been ſeen in kids by Eraſiſtratus, which appear to have been lacteals, though he called them arteries. Theſe lacteals were, however, firſt accurately diſtinguiſhed in 1622, by Aſellius, who printed his account in 1627. In 1651, Pecquet publiſhed his account of the thoracic duct, which appears, however, to have been ſeen before by Euſtachius. In 1653, Bartholin publiſhed on the lymphatics, which had been ſome time before diſcovered by Rudbeck. In 1654, Gliſſon aſcribed to theſe veſſels the office of carrying back the lubricating lymph from the arteries into the blood, or conſidered them as abſorbents. In 1664, the valves of theſe veſſels were diſcovered by Swammerdam, and a year after, an account of them was given by Ruyſch. The farther diſcoveries of Nuck, Nouges, Warton, Steno, Hunter, Monro, Hewſon, Cruikſhank, Sheldon, Maſcagni, &c. have nearly completed our knowledge of the abſorbent ſyſtem, and its uſes.

41 Diſcovery of the abſorbent ſyſtem.

In the latter end of the 17th century, ſome important diſcoveries were made on the ſubject of reſpiration, by our countryman Mayow; and theſe were ſupported by the obſervations of Lower, Verheyen, and Borelli. Theſe diſcoveries, however, lay dormant till they were brought into recollection a hundred years after in conſequence of the experiments of Prieſtley and Lavoiſier.

During the 17th century, conſiderable progreſs was made in completing the knowledge of the internal organs of generation. Much was done in this way by De Graaff and Malpighi, and Leuwenhoeck, the two latter of whom made ſeveral diſcoveries with the aſſiſtance of their microſcopes, though Leuwenhoeck founded on his obſervations a theory of generation which at this day appears not a little ridiculous.

42 Syſtem of Boerhaave.

The beginning of the 18th century is remarkable for the promulgation of a new phyſiological doctrine, founded on a miſtaken application of the circulation of the blood. We allude to the ſyſtem of Boerhaave. This great phyſician ſuppoſed that all the functions of the living body, excepting the will, are carried on by mechanical movements, ſuſceptible of rigid calculation, which neceſſarily ſucceed each other in the organs, from the time that life commences. Theſe movements are brought into action as ſoon as the animal begins to reſpire, and are the conſequence of an impulſive power in the heart, renewed by means of the influence of the nervous fluid brought from the brain. He conceived the living body to be merely a hydraulic machine, in which the heart performs the office of a piſton, and that the alternate contractions and dilatations that take place without intermiſſion in that organ, are owing to the alternately increaſed and diminiſhed compreſſion of the nerves that are diſtributed to the heart. When a contraction takes place, the blood fills the large arteries, and thus diſtends and compreſſes them; when the principal nerves of the heart, which paſs between theſe arteries, muſt of courſe become compreſſed, and thus their influence being diminiſhed, a relaxation takes place. But in proportion as the heart is relaxed, the large arteries become empty, and conſequently ceaſe to compreſs the nerves, which thus recovering their influence, reanimate the heart to a new contraction. Thus ſucceed each other without interruption the movements which form the mechanical principle of all the ſenſible motions that we obſerve in the animal machine.

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Proceeding on these principles, Boerhaave conceived some very strange notions respecting the constituent properties of the living fluids, in which he saw no other mark of vitality than the globular form of their particles. He confined all the functions of the several organs to the operation of rounding into spheres the particles of the fluids which were presented to them, or of preserving that form in those which they already contained. He thought that the lungs were chiefly of advantage, because they contained within them a complete series of vessels, in which the particles of the blood can receive all those dimensions which may fit them to circulate through the rest of the body. The greater or less velocity with which the fluids circulate through the secretory organs, constitutes the principal difference in the nature of the secretions. Various orders of vessels receive the blood and other fluids which pass through these divisions, subject to the laws of hydraulics; and when a fluid got by chance into an order of vessels that was not fitted to receive it, some disease was the consequence. Every thing in the animal machine was reduced to an assemblage of conduits, canals, cords, levers, pulleys, and other mechanical contrivances, put into action by mechanical means.

43 Mechanists.

Thus was completed the system of mechanical physiology, which was begun some time before by Bellini and Borelli; and this system maintained its ground in defiance of observation and common sense, till about the middle of the 18th century. In the mean time, however, there arose two men, whose enlarged ideas and acute genius induced them to dissent from the received opinions of the day, and to think for themselves. These were Hoffman and Stahl, who, though they did not, any more than Boerhaave, form complete or unobjectionable theories, contributed much to improve our ideas of the animal economy.

44 System of Hoffman.

Hoffman saw, that in the living body we ought not to separate the principle of vitality from the general properties of matter. He believed that that principle, susceptible in itself of activity and motion, was sufficient for all the occasions and all the functions of the body which it animated. The animal body was not, in his eyes, an hydraulical elastic machine, formed of solids and canals, differing only in size, form, elasticity and force. He saw, that if the solids act upon the fluids, these must, in their turn, react upon the solids; and that life could subsist only by these mutual actions and reactions. The essential cause of life, according to Hoffman, is the progressive motion of the blood, occasioned by the impulse of the heart, and kept up by the alternate contractions and dilatations of the vessels. These contractions and dilatations are the consequence of the force of an elasticity inherent in the vascular fibres, and this force is still farther promoted by the different structure of these elastic fibres, which is such that they can be penetrated by the blood and the nervous fluid. This last fluid he imagined to be composed of aerial and etherial particles enveloped in a certain portion of a very pure subtile lymph, that served them as a vehicle. By this fluid the cavities of the nerves are filled, and it constitutes the sensitive soul, in which resides the seat of the passions. Now, all the functions, even those which we attribute to a sentient principle, are the effect of physical powers, whose mechanism has, however, something more sublime and more exalted with respect to the animal operations than to others. If all the nervous, vascular, and membranous parts, preserve a moderate degree of action, and a moderate state of tension and relaxation, the solids are subjected to oscillatory motions which balance each other, and produce a proper equilibrium in the system. In this state, all the operations of the body and the mind take place with proper regularity; and this happy harmony, by assuring to the animal the entire plenitude of its existence, becomes the foundation of health. This degree of moderate tension is always more or less altered in a state of disease.

45 Of Stahl.

Little satisfied with all the theories founded on a gross mechanism, and convinced of their insufficiency to explain the phenomena of vitality, Stahl admitted forces that were something more than mechanical, and that were directed by an intelligent principle which applies them to their destined uses, and which, by distributing them with a wise economy, proportions or accommodates them to the different occasions of the individual. His disciples consider Stahl as the first modern writer who has treated the science of man on a general plan, and according to a philosophical arrangement; and as his doctrine has still numerous advocates in the medical schools of France, we shall be somewhat more particular on it than on that of Hoffman.

In determining the limits between medicine and the other physical sciences, Stahl commences with separating from the former all those principles which, though true in themselves, have no relation to the nature of that science, which he considers as originating in observation alone. The knowledge of the physical state of the animal body cannot, he thinks, throw any light, either on the injuries to which it is exposed, or on the means of preventing or removing them. Consequently it is of little use in medicine, and has no right to govern an art, the object of which is, to remedy those injuries that threaten the human body. He proves that living bodies are freed from the necessary laws of mechanics, because all their actions tend to one common end;—an end which embraces the whole chain of the movements essential to life, and the means established for its preservation. The human body, by means of this mixture of mechanical and vital powers, tends naturally to self-destruction; but, on the other hand, the organic structure to which is attached the exercise of the actions peculiar to the human species, is founded on this mixture. It is therefore necessary that the body should be in a state of resisting this tendency, in order that it may be sustained; and as the corruptibility inherent in its nature, pursues it through every period of its existence, the opposing action necessary to prevent the corruption from taking place, must also be exercised without intermission. It is this preserving action that constitutes the essence of life.

The preservation of the body is indeed effected by a sort of mechanical action; it requires the corporeal organs as its instruments, and it depends on different coexistent and successive actions. Health is the result of that just conformation of the organs which enables them to perform their functions with ease.

The exact conformity which subsists between the structure of each organ, and the functions it is destined to perform, demonstrates to the philosophical eye an intelligent and wise principle, that in the formation of organized bodies directs and prescribes every thing in the

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the manner most favourable to the end which it proposes. A speculative metaphysician, accustomed to wander over the field of abstraction, to enlarge the sphere of his intellectual notions, to transform sensible objects into ideas, this author could never persuade himself that a being could not proportion and adapt its organs to the operations they are to perform, without possessing a knowledge of these operations, and having already exercised a judgment with respect to them. It is from this that he confounds the principle of life with the thinking soul, which being incessantly present in every part of the body, directs and disposes them according to its own views, and to the end that it proposes in the continual developement of the actions it is to conduct.

The formation, the structure, duration and movements of the body, do not belong peculiarly to it, as it is only a passive subject on which the soul impresses and realises the idea of the phenomena that she has conceived. Every thing is derived from the union of the body with the active foreseeing principle, which governs, according to special laws, those phenomena which are more particularly vital, and which are most independent of the will. The immediate action of this latter faculty does not require the assistance of any other substance. The intervention of an intermediate principle would be there superfluous; and Stahl rejects that of the animal spirits, which had been introduced to explain the mechanism of vitality, and which, by overcharging the science, embarrasses it with a useless hypothesis.

Two faculties are sufficient for the soul to act upon the body, and to preserve it in a living state, viz. those of sense and motion. By the former the animal learns to know the properties of the objects by which he is surrounded, or in which he is interested, and to estimate the relations that subsist between these objects and himself; the latter produces the motion of the whole machine, and determines all the changes of situation which it has to undergo in its whole, and in its parts.

The faculty of sensation has two modifications, relative to the two kinds of knowledge which the soul may receive by means of that function. The first of these resides in the organs of sense, and is adapted to external objects; the second establishes its seat in the interior organs, and refers to objects that are within, or ideas. Sometimes the moving power enveloped in the muscular system is displayed by the sensible actions that regulate the position of the body with respect to the objects of the universe, of which it makes a part; sometimes concentrated within these organs, it excites intestinal motions, which maintain among their constituent parts, those relations, and that equilibrium, which are necessary to preserve the healthy state, consistence, and tone of each organ. The muscular apparatus is subservient to the exercise of the senses; and the different motions which it impresses on the body, for the purpose of transporting it towards, or to a distance from, certain objects, are always determined by the convenience or inconvenience which the body, by means of the senses, experiences from those objects. The tonic motion, determined by the confused ideas of the principle of life, is displayed in the most hidden organic parts, in the most perfect repose and profound silence of the voluntary movements.

The soul gives to its organs the disposition that is favourable to the sensations it wishes to receive, by virtue of the judgement that it exerts respecting these sensations, before it has experienced them. This judgement is exerted on the relations between the objects that excite these impressions, and the actual state of the body; and it is the intuitive knowledge of these relations that determines, in all their infinitely diversified shades, the pleasure or the pain which the animal experiences from the objects that surround it.

Stahl regards the excretions as the means employed by nature to counteract the natural tendency of the body towards putrefaction. He believes that the animal humours are exceedingly disposed to thicken, and that the circulation of the blood is the means made use by nature to keep up their original fluidity. One of the causes that most favour the tendency of the humours to putrefaction, is *plethora*, to which nature opposes, sometimes the motion of the solids that distribute the blood; sometimes the hemorrhagic fluxes which unload the vascular system. These latter opinions are the principal foundations of what has been called the *humoral pathology*, which prevailed so long in most of our medical schools, and which, with certain modifications is still maintained in many parts of the continent.

46 Of Haller.

The favourable impulse given to physical science in general, by the philosophical writings of Bacon and Newton, extended itself at length to physiology; and physiological writers became convinced that it was better to collect and arrange the facts that related to the economy of living beings, than to frame hypothetical systems concerning them. The honour of forming a rational digest of the phenomena of the animal economy was reserved for Haller, who perceived the importance of assembling under one view, the experiments, facts, and observations of preceding writers, and of substituting them in the place of hypothetical reasonings. He traced the plan of the immense edifice that he designed to construct in his *First Lines of Physiology*, and executed it on a grand and extensive scale, in his *Elements*, in which he has brought together into a body of doctrine, as complete as could be expected in his time, all the materials of the science. He perceived the inconvenience of a too strict application of the laws of mechanical philosophy to the living system. He admitted an active force, which he considered as peculiar to the animal body, viz. irritability, which contains the reason or the experimental cause of muscular motion. He maintained that irritability should never be confounded with sensibility, and that the irritable fibre differs as much from the sensible fibre, as the function of motion from that of sensation. Lastly, in his *Opera Minora*, he lays down many new and important points of doctrine respecting the structure of our organs, and the mechanism of our functions; and he relates a number of experiments made on living animals, for the purpose of drawing from nature the secret of those phenomena which she appears most desirous to conceal. We owe to Haller some curious researches respecting the formation of bone, and the production of callus, as well as some important elucidations of the manner in which the embryo contained in the egg is developed, and passes through the successive stages of its organization. He has left us many experiments and details respecting the structure of the heart, the circulation of the blood, and the pulsation of the arteries; on the mechanism of the ribs, and the action of the intercostal muscles during respiration; on the differences between the sensible and irritable organs; on the action of the brain and nerves, &c.

The

History. The latter half of the 18th century is remarkable for many able phyſiologiſts, who will be admired by poſterity, either for the acuteneſs of their genius, or the important improvements that they have made in the ſcience. We may mention the names of Bordeu, La Caze, Bonnet, Vicq d'Azyr, Bichat, Dumas, and Cuvier in France; of Fontana and Spallanzani in Italy, and of Whytt, Cullen, Brown, and Darwin in Britain. We cannot pretend to enumerate all the opinions and diſcoveries of theſe celebrated men, but muſt content ourſelves with giving a ſketch of the three rival ſyſtems of Cullen, Brown, and Darwin, and a brief outline of the opinions of Bichat.

47 Of Cullen. The phyſiological ſyſtem of Cullen was founded chiefly on that of Hoffman. He placed the principle of the whole animal economy in the movement of the vital ſolids, regulated by the fundamental laws of the nervous ſyſtem. This notion of the vital ſolids, according to him, originates in the nerves, and being almoſt always united in the *ſenſorium*, is eaſily tranſmitted from one nervous part to another, as long as the medullary ſubſtance of the nerves continues in its natural ſtate of life and continuity. The contraction of the moving fibres connected with the ſenſible organs through the medium of the brain, is the direct effect of a movement that commences with thoſe objects. It is on the contractility inherent in the moving fibres, excited by their own extenſion, by the application of various ſtimuli, and often by the immediate influence of the animal or nervous powers, that all the phyſical actions of a living being depend. He regards this contractile force as diſtinct from all thoſe which are poſſeſſed by the ſimple ſolid, and the inorganic elaſtic parts of the body.

Of the theory of Brown, we have given a ſufficient detail under his life, and need not repeat it here.

48 Of Darwin. It is not eaſy to give a compendious view of the ſyſtem of Dr Darwin, that ſhall be intelligible to thoſe who have not examined his celebrated work, the Zoonomia; but we ſhall endeavour to give as brief and perſpicuous an account of it as poſſible. It is neceſſary firſt to notice the deſcriptions given of the terms to be employed, which are as follows.

The immediate organs of ſenſe are, by Dr Darwin, aſſerted to conſiſt, like the muſcles, of moving fibres. The contractions of the muſcles and of the organs of ſenſe, are comprehended under what are called *fibrous motions*, in contradiſtinction to the *ſenſorial motions*, or the changes which occaſionally take place in the *ſenſorium*. By this latter term is underſtood, not only the *medulla* of the brain and nerves, but alſo at the ſame time that living principle or *ſpirit of animation*, which reſides throughout the body, and which we perceive only in its effects. An idea is defined to be a motion of the fibres of ſome immediate organ of ſenſe; and hence is frequently termed alſo a *ſenſual motion*. Perception comprehends both the fibrous motion or idea, and the attention to it. When the pain or pleaſure ariſing from this motion and this attention produces other fibrous motion, it is termed *ſenſation*; thus limiting this term to an active ſenſe. Ideas, not immediately excited by external objects, but which recur without them, are termed either, 1. Ideas of *recollection*, as when we will to repeat the alphabet backwards; or 2. Ideas of *ſuggeſtion*, as when we repeat it forwards, A ſuggeſting B, B ſuggeſting C, &c. from habit.

After mentioning a number of experiments to prove the fibrous motions of the organs of ſenſe, Dr Darwin proceeds to lay down the following laws of animal cauſation. History.

1. The fibres which conſtitute the muſcles, and organs of ſenſe, poſſeſs a power of contraction. The circumſtances attending the exertion of this power of *contraction* conſtitute the laws of *animal* motion, as the circumſtances attending the exertion of the power of attraction conſtitute the laws of *inanimate* matter.

2. The *ſpirit of animation* is the *immediate* cauſe of the contraction of animal fibres. It reſides in the brain and nerves, and is liable to general or *partial* diminution or accumulation.

3. The ſtimulus of bodies external to the moving organ is the *remote* cauſe of the original contractions of animal fibres.

4. A certain quantity of ſtimulus produces *irritation*, which is an exertion of the ſpirit of animation exciting the fibres to contraction.

5. A certain quantity of contraction of animal fibres, if it be perceived at all, produces *pleaſure*; a greater or leſs quantity of contraction, if it be perceived at all, produces *pain*. Theſe conſtitute *ſenſation*.

6. A certain quantity of ſenſation produces *deſire* or *averſion*. Theſe conſtitute *volition*.

7. All animal motions which have occurred at the ſame time or in immediate ſucceſſion, become ſo connected, that when one of them is reproduced, others have a tendency to accompany or ſucceed it. When fibrous contractions ſucceed or accompany other fibrous contractions, the connection is termed *aſſociation*; when fibrous contractions ſucceed ſenſorial motions, the connection is termed *cauſation*; when fibrous and ſenſorial motions reciprocally introduce each other, it is termed *catenation of animal motions*. All theſe connections are ſaid to be produced by habit; that is, by frequent repetition. Theſe laws of animal cauſation are, according to our author, evinced by numerous facts, which occur in our daily exertions, and are employed by him to explain the diſeaſes and decay of the animal ſyſtem.

The four *ſenſorial powers*, upon which all the actions or motions depend, are thus characterized:

Irritation is an exertion or change of ſome extreme part of the ſenſorium, preſiding in the muſcles or organs of ſenſe, in conſequence of the appulſes of external bodies.

Senſation, is an exertion or change of the central parts of the ſenſorium, or the whole of it, beginning in ſome of thoſe extreme parts of it, which reſide in the muſcles or organs of ſenſe.

Volition is an exertion or change of the central parts of the ſenſorium, or of the whole of it, terminating in ſome of thoſe extreme parts of it which reſide in the muſcles or organs of ſenſe.

Aſſociation is an exertion or change of ſome extreme part of the ſenſorium, reſiding in the muſcles or organs of ſenſe, in conſequence of ſome antecedent or attendant fibrous contractions.

To theſe four faculties correſpond ſo many claſſes of fibrous contractions, named *irritative*, *ſenſitive*, *voluntary*, and *aſſociate*. But all muſcular motions, and all ideas, are originally irritative, and become cauſable by ſenſation and volition from habit, i. e. becauſe *pleaſure* or *pain*, or *deſire* or *averſion*, have accompanied them;

 thoſe

those ideas or muscular motions which have been frequently excited together, ever afterwards have a tendency to accompany each other.

Of these motions the *associate* seem most to have excited Dr Darwin's attention. He divides them into three kinds; *irritative associations*, as when any part of the extracted heart of a frog is irritated by puncture, the whole heart contracts regularly; *sensitive associations*, or the trains or tribes of motions established by pain or pleasure; and *voluntary associations*, or those produced by volition.

The activity of this power of volition is supposed to form the great difference between man and the brute creation; the means of producing pleasure and avoiding pain given to man by this power being denied to brutes.

Corresponding to these four classes of motions, there are four classes of ideas; *irritative*, preceded by irritation; *sensitive*, preceded by the sensation of pleasure or pain; *voluntary*, preceded by voluntary exertion; and *associate*, preceded by other ideas or muscular motions.

It has been observed in Hudibras that

> "———A rhetorician's rules
> Serve nothing but to name his tools."

So we find that a considerable part of Darwin's work is taken up in establishing the new meaning which he attaches to terms well understood and long adopted.

We cannot enter more fully at present into the opinions of the Zoonomia, but we shall have occasion to notice some of them in the succeeding part of this article.

49 Opinions and arrangement of Bichat.

Bichat's system, which has made so much noise on the continent, is chiefly founded on the division of life into two kinds, *organic* and *animal*; the former of which is common to all organized beings, while the latter, as its name imports, is peculiar to animals. Each of these two kinds of life may be considered as composed of two orders of functions, which succeed each other in an inverse order. The first of these series in *animal life* commences with external objects, and proceeds towards the brain; the second begins in the brain, and is thence propagated to the organs of motion and voice. In the first order of functions, the animal is passive; in the second he is active. External objects act on the body through the medium of the first; by the second, the body reacts on external objects.

Two kinds of motion take place in *organic life*. In the first the formation of the body is constantly going on; in the second there is a constant decomposition: hence the elements of the body are continually changing, while the organization continues the same. Organic life is accommodated to the continual circulation of matter. The one order of functions assimilates to the nature of the animal, the nutritious particles received into the system; the other rejects what is useless, or is so much altered as to become noxious. The assimilating order of functions consists of digestion, circulation, respiration, and nutrition; all of which processes the matter received into the body must undergo, before it can become a part of the animal substance. When it has for some time constituted a part of the body, it is taken up by absorption, conveyed into the circulation, and thrown out thence, by cutaneous or pulmonary exhalation, or by some other emunctories. Hence, the second order of organic functions, or disassimilating functions, consist of absorption, circulation, exhalation, secretion, and excretion. The *brain* is the centre of *animal life*; the *heart* of *organic life*.

Bichat considers the proper balance of life to be preserved by the proportion which exists between the action of surrounding bodies, and the reaction of the system. This reaction is greatest in youth, hence the principle of life is at that time in excess. It is least in old age, and then the vital principle is defective. The measure of life is therefore the difference which exists between the efforts of external powers to overturn life, and the internal resistance to support it. The excess of the former shows the weakness of life; that of the latter indicates its strength.

The following table exhibits Bichat's distribution of he organs, or, as he calls them, *appareils*, belonging to *animal* and *organic life*, and to *generation*, which is common to both.

I. Organs of Animal Life.

Organs	1. *Locomotive*,	including	1. The bones and their dependances. 2. The muscles and their dependances.
	2. *Vocal*, including the larynx and its dependances.		
	3. *External sensitive*,	including	1. The eye. 2. The ear. 3. The nostrils. 4. The tongue. 5. The skin and its dependances.
	4. *Internal sensitive*,	including	1. The brain and its membranes. 2. The spinal marrow and its membranes.
	5. *Conducting sensation and motion*,	including	1. The cerebral nerves. 2. The nerves of the *ganglia*.

II. Organs of Organic Life.

Organs			
1. *Digestive,*	including	1. The mouth.	
		2. The pharynx and *œsophagus.*	
		3. The stomach.	
		4. The small intestines.	
		5. The large intestines.	
		6. The *peritonæum* and *epiploon.*	
2. *Respiratory,*	including	1. The *trachea.*	
		2. The lungs and their membranes.	
3. *Circulatory,*	including	1. The heart and its membranes.	
		2. The arteries.	
		3. The veins of the general system.	
		4. The veins of the abdominal system.	
4. *Absorbent,*	including	1. The absorbent glands.	
		2. The absorbent vessels.	
5. *Secretory,*	including	1. The lachrymal ducts.	
		2. The salivary and pancreatic ducts.	
		3. The biliary and splenic ducts.	
		4. The urinary passages.	

III. Organs of Generation.

Organs.		
1. *Male.*		
2. *Female.*		
3. *Produced by this union,*	including	1. The membranes and placenta.
		2. The fœtus.

50 Recapitulation. We have now taken such a view of the progressive state of physiological science, as we deemed consistent with the nature and extent of this article. It has taught us that the prevailing spirit of every age has had a marked influence on the productions both of art and science that have appeared during that period; and that physiology has always been impressed with the character of the science that was most prevalent at any particular period. While the doctrines of Aristotle prevailed in the schools, physiology never extended beyond the bounds that had been set to it by Galen; and the belief in occult qualities universally prevailed. When a taste for metaphysical speculations began to gain ground, this science was given over to the most abstract subtilities and absurd fictions. When Des Cartes had reformed the principles of the ancient philosophy, the study of the animal economy, like all the other branches of physics, was fettered by the trammels of the Cartesian doctrines. After the genius of philosophers was directed to chemistry, physiology also took a chemical turn, which it quitted only to take a new direction pointed out to it by the taste for mathematics and mechanical philosophy, which prevailed among all the literary at the end of the 17th and beginning of the 18th century; and now that the study of chemistry is become so general, we see that physiologists are for reducing the functions of the animal economy to the analytical and synthetical operations of the laboratory, and converting the living body into a furnace where a constant combustion is going on while life remains.

We are now to enter on the phenomena of life, and the functions of organized beings; and here we must premise, that in our illustration of these phenomena and functions we shall occasionally refer to every class of living creatures; it being our object rather to give a comparative view of physiology in general, than to confine our remarks to the human economy in particular. Indeed much of the physiology of man has already been given under Anatomy and Medicine; and of that of the inferior animals, we have treated of the physiology of the order *Cete* under Cetology; of that of *Reptiles* under Erpetology; of that of *Fishes* under Ichthyology; of that of *Serpents* under Ophiology.

Chap. I. *Of the General Phenomena of Life.*

When we take a general view of the objects of nature, we see that they differ from each other in many important particulars, and we soon find that they may be conveniently divided into two great classes; one capable of growth, nourishment, and reproduction; the other not susceptible of these changes. We perceive that all those substances which are found in the bowels of the earth, and many of those which appear upon its surface, continue for an indefinite time in the same circumstances, until they are acted on by each other, when they undergo certain changes which entirely alter their nature and former properties. 51 General idea of life.

Sulphur, in its natural state, is a solid substance insoluble in water, and possessing little activity when applied to the human skin; but if it be subjected to the action of heat, in contact with atmospheric air, or any other gas containing oxygen, it becomes a fluid, very miscible with water, and of a most corrosive quality, namely sulphuric acid. The hydrogenous gas found in the upper part of mines, would remain for ever uncombined with the oxygenous gas which forms part of the atmosphere in which it floats, were it not subjected to the action of caloric, or electricity in a very concentrat-ed ed state; but as soon as either of these agents comes in contact with the mechanical mixture of gases, a combination takes place, attended with a tremendous explosion, and the hydrogenous gas disappears.

52 Distinction between organized and inorganic matter.

We find that all the bodies to which we give the name of minerals, possess no power in themselves which can enable them to resist the operation of external agents; each individual of them is composed of a small number of principles, and their texture appears to be made up of independent particles. Every other body in nature, comprehending the almost infinite variety of plants and animals, though under certain circumstances subject to the same changes which take place among minerals, have, when these circumstances do not exist, an innate property by which they are enabled to resist the production of these changes. They do indeed undergo certain alterations, but by these their original habit and essential properties are not changed. From the time that a plant springs from the seed, till it ceases to vegetate, it is perpetually receiving an accession of new matter, and giving out a part of its former composition: but the new matter is assimilated to it, and becomes a part of the plant; the identity of the plant is preserved, though its component parts are perpetually changing. The same in a still higher degree takes place in animals. The individuals of this latter class, comprehending plants and animals, possess peculiar structure, very different from that of the former. Their texture is fibrous, and the fibres arranged and interwoven, so as to form parts called organs, by means of which they carry on certain operations or *functions* necessary for their preservation, or for the reproduction of the species. Hence these have been called *organized* bodies, while the others have been denominated *brute* or *inorganic* matter. See NATURAL *History*, N° 7.

The component principles of organized beings are much more numerous in each individual than those of inorganic matter, though their absolute number in the former class is smaller than in the latter. In order to present, under a compendious point of view, the distinguishing characteristics of these two classes of beings, we shall give the following table.

The phenomena of inorganic matter are	Mobility, Repose, Aggregation, Cohesion, Gravitation, Condensation, Dilatation, Combination, Dissolution.	Resolvable into	Inertia, Impulsion, Attraction, Affinity.
The phenomena of organized matter, besides those of inorganic matter are,	Impression, Sensation, Perception, Affection, Sympathy, Action, Locomotion, Digestion, Circulation, Respiration, Assimilation, Accretion, Reproduction.	Resolvable into four general forces,	Sensitive, Motive, Assimilative, and Vital resistance.

The properties of inorganic matter are,	Extension, Gravity, Hardness, Elasticity, Fluidity, Impenetrability, Divisibility, Expansibility, Permeability, Figurability.	The variations or degrees of which distinguish	Crystals, Salts, Metals, Stones, Fossils.
The properties of organized matter, besides those of inorganic matter are	Regularity, Individuality, Spontaneity, Sensibility, Contractility. Irritability, Expansibility, Corruptibility.	The variations or degree of which distinguish	Man, Mammalia, Birds, Reptiles, Serpents, Fishes, Mollusca, Crustacea, Insects, Worms, Zoophytes, Plants.

53 Effects of life.

The differences that are found to prevail between organized beings and inorganic matter, have always been attributed to something of a superior nature, called vitality or life. This term life forms one of those simple ideas which it is difficult to define, and as all understand the meaning of the expression, a definition is the less necessary; but if it be required, it cannot be expressed more accurately than in the language of Bichat, who calls life *the sum of those functions which resist death.* In short, life is best described by the effects produced on a body while it resides in it, contrasted with these appearances which take place in the same body when life is no longer present.

54 Resistance to chemical change.

One of the most general effects of the presence of life is, as we have said, the resistance which living beings are by it enabled to oppose to the operation of external agents; and this is most remarkably seen with respect to temperature. Every living being possesses, in a greater or less degree, the power of preserving nearly an uniform temperature, which is always a few degrees greater than that of the medium in which it lives. In plants, this power seems to exist but in a low degree. Some of the lower animals which inhabit the air, particularly insects, possess it much more completely. The great heat generated in a hive of bees is a familiar illustration of this. In birds this property is very remarkable, the heat of their bodies being greater than that of any other species of animals. The heat of fishes, worms, and of most reptiles, very little exceeds the temperature of the medium in which they reside; but when the water in which fishes live is frozen, they are capable of resisting, for a long time, the consequences of the diminished temperature. The power which many animals possess of resisting high degrees of heat without any considerable increase of their own temperature, seems still more remarkable, and probably led to the fable of the salamander, which was supposed able to endure the heat of fire, and even extinguish it, when thrown in for that purpose.

55 Degrees of vitality.

Life seems to pervade almost every part of a living being. In animals, every part except the cuticle, hair, and nails, exhibit marks of vitality; but it seems to be distributed

General Phenomena of Life. tributed through those parts in a different manner in the various tribes of organized beings. In plants, and in a few of the inferior animals, as the zoophyta, it seems to exist independently in almost every part. A bud, slip, or sucker, torn from the parent plant, and inserted within the bark of another plant, or placed within the earth, in favourable circumstances, vegetates, increases, and in due time becomes a perfect plant, in all respects similar to the parent stock. If a polypus be cut in pieces, each piece lives and grows, till it becomes itself a complete polypus. If a worm be cut in two, so as to leave one part with the head, and the other with the tail, each part becomes a perfect worm, possessing both head and tail. As we ascend, however, in the scale of beings, we find life less equally and independently diffused. A part cut or torn from the body of most animals quickly loses its vitality; but this is lost sooner in some animals than in others. The head of a turtle or a snake is able to bite many hours or even days, after it is severed from the body; and in the former instance, the animal seems for a long time to experience little inconvenience from its loss. The heart of a frog is seen to move many hours after it is cut out.

56 Functions of living beings. The principal effects of the presence of life appear in the exercise of those functions or actions by which living beings preserve their existence, or reproduce their like.

57 Motion. One of the most general properties of organized beings is that susceptibility to motion, which is called irritability, which appears essential to life, and is possessed, in a greater or less degree, by every class of organized beings. The motions of plants are sometimes very remarkable, and approach very nearly to those which take place in animals. The stamina of the *cistus helianthemum* are seen to move in various directions when the sun shines on them; the leaves of the *mimosa pudica* (sensitive plant), when touched by the hand, or when irritated by the alighting of an insect on them, immediately contract; the *dionæa muscipula* (Venus's fly-trap), when a fly touches its leaves, closes the thorny fringes with which they are beset, on the presumptuous insect, and crushes it to death; but the motions of the *hedysarum gyrans* are the most remarkable of all those that take place in plants. The leaves of this extraordinary vegetable are seen in constant motion through the greatest part of the day, without the intervention of any apparent external impulse; and even when a branch is cut off and kept in water, the motion of the leaves continues for many hours together. All the plants which grow above the earth, expose their leaves and flowers to the warm sunshine, and when situated in a place which is supplied by light only from one quarter, they gradually direct their branches towards that part by which the light enters. In stormy weather they retract their leaves, and fold up their flowers, and when confined in the dark, their branches retain the position which they had when last exposed to the light.

The motions of many of the lower animals, though sufficiently apparent, are more obscure than those of plants. A muscle or an oyster seems to possess little more motion than is necessary to open and close the valves of its shell, and, no more than plants, has the faculty of conveying itself from place to place. This faculty of locomotion, which in all the higher classes of animals is dependent on the will, will be fully considered in the second chapter.

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The function which appears to be most universally diffused in living beings, is digestion, (including nutrition) or that by which the substances intended for their nourishment are assimilated to the nature of the body which they enter. This function varies considerably in the different classes. Plants merely attract water from the earth in which they grow, by means of the fibrous parts of their roots, whence it is conveyed by innumerable capillary vessels throughout the whole plant, in which it appears partly to be decomposed, and partly to remain in the state of water, diluting some of the vegetable principles, and thus forming the juices of the plant. In some of the inferior animals, digestion seems to be almost the only function which they are capable of performing. Thus, many of the zoophytes, as the polypi, appear to be almost entirely composed of a stomach, resembling the finger of a glove, into which the aliment is received, the nutritive part extracted, and the excrementitious part thrown out by the same opening. In most other animals, the alimentary canal has two distinct openings, one for the reception of the food, and the other for the ejection of the excrement. 58 Digestion.

By some animals the food is swallowed entire, and digestion is performed by a simple solution or trituration in the stomach; while in others the mouth is furnished with teeth, or other hard parts, capable of reducing the aliment to a pulpy state, in order to render its further digestion more easy and expeditious. In most animals, the food having undergone some change in the digestive organs, is taken up from them by certain very minute vessels, and carried to every part of the body; but in some it appears rather to exude through pores in the sides of the alimentary canal.

The function of circulation, by which the fluids are constantly moved through every part of the body, is not so general as either of the former functions. In plants there is no proper circulation; for although there are numerous vessels by which water enters into the substance of the plant, and in which the peculiar juices of the vegetable move, the motions of these fluids are not uniform, and do not tend towards one centre. The same defective circulation appears in many of the inferior animals, as in zoophytes and insects. As we rise, however, to the higher classes, we find a perfect circulation. In these there is always a peculiar organ from which the fluids are conveyed to the rest of the body, and to which they again return in a perpetual round. In some animals this central organ is single, while in others it consists of two similar organs joined together, from one of which the whole of the fluids proceed thro' one particular organ in a lesser circulation, and thence return to the other part, before they are distributed to the general system. 59 Circulation.

All organized beings require more or less the presence of atmospheric air for their subsistence, or at least for the due performance of the vital functions. In some, the agency of this fluid is conveyed merely by pores upon the surface; as in plants, in which the leaves absorb the air; and in several of the inferior animals, as insects and worms, over the surface of whose bodies are distributed numerous openings, by which the air enters. In animals of the higher orders there are peculiar organs called 60 Respiration.

General Phenomena of Life.

called lungs or gills, through which air, or water containing air, enters, and from which its beneficial influence is imparted to the fluids which are circulating through them. In general, these beings exist for a very short time, when deprived of atmospheric air, or when the element in which they live is deprived of oxygen: but in some of the lower classes of animals the absence of oxygen is much less injurious; and there are instances of reptiles in particular having been preserved in a state susceptible of life and motion, while buried for many years in the heart of a tree, or in the middle of a block of stone. Respiration, then, though in general necessary to the continuance of vitality, may, in many tribes of organized beings, be suspended for a considerable time, without the principle of life being entirely destroyed.

61 Reproduction.

A function equally general, aud equally indispensible with that of digestion, and one which forms another characteristic of living beings, is the function of regeneration, a function more peculiarly necessary, as all organized beings, though capable of resisting for a considerable time the operation of external agents, tend ultimately to corruption and decay; and as they cannot, like inorganic matter, be regenerated by a reunion of their component principles, it was necessary that they should possess the capacity of producing, while in existence, a creature similar to themselves, to supply their place in the scale of being.

It has been a very general opinion among naturalists, that all living beings, both plants and animals, originate from seeds or eggs produced by the parent. This, although very generally true, is not a universal fact. Most plants, indeed, with which we are acquainted, appear capable, in their natural state, of producing seeds, which form the embryo of a future plant. But in a great many of them new plants are obtained from buds, slips, or suckers, furnished by the parent. In some animals too, as the polypi, reproduction may be effected by dividing the parent into several pieces; and even the natural generation of these animals is performed by protuberances which grow from the body of the parent, and seem to drop off spontaneously, when capable of an independent existence.

There are two striking differences in the manner by which living beings are generated. In some, two distinct sets of organs are necessary, and by the mutual action of these generation is effected; while in others, as in the instances we have mentioned of the polypus, this act of copulation appears to be unnecessary. Almost all plants possess distinct sexual organs, and in most both male and female organs are situated in the same individual. In these plants the female ovum is impregated by a very fine powder, which is contained in part of the male organs, and is applied to those of the female. We are fully convinced of the necessity of the vegetable copulation, by observing that the females of those plants which have the sexual organs situated in distinct individuals are not capable of producing fruit, or at least do not produce this in perfection, if they are excluded from the influence of the male; and that an artificial impregnation may be brought about by bringing the male and female organs in contact. Many animals are hermaphrodite; and among these the individuals of some species generate without the assistance of another individual of the same species. This appears to be the case with the bivalve shell-fish. Others again, as snails, and most of the mollusca, which crawl upon the earth, copulate reciprocally, or each individual performs the double office of male and female. In most animals, however, the sexes are distinct, and probably a real hermaphrodite in the superior classes never existed. Another striking difference with respect to generation in animals is the more or less perfect state in which they bring forth their young. A large proportion of animals, among which are the insect tribe, fishes and birds, produce eggs, which are afterwards hatched by the heat of the parent, or by that of the sun. Other classes again, as some of the amphibia, and the whole of the mammalia, carry their young for a certain time within an organ destined for that purpose, from which they are excluded in the state of perfect animals.

62 Sensation.

The last function which we shall here notice, is sensation. This appears to be less general than any which we have hitherto mentioned. It has indeed been supposed by many philosophers and naturalists, that plants possess a degree of sensibility; and this opinion has been lately avowed and strenuously supported by the elegant, but enthusiastic author of the Botanic Garden, and the Loves of the Plants. That plants possess a susceptibility of receiving impressions, and in consequence of that of being roused into action by external stimuli, we shall readily admit, and shall hereafter assign to this susceptibility its due importance; but as there is no reason to believe that it ever produces sensation, we must not confound it with the sensibility of animals; nor is the difficulty of explaining some of the functions of vegetables, without resorting to the hypothesis of a vegetable sensorium, a sufficient reason for investing them with this faculty. It has even been doubted whether some of the inferior animals, as the zoophytes, possess this function, as nervous fibres have not yet been detected in their organization. It is probable, that there is a regular gradation in the tribes of organized beings with respect to sensation, as well as the other functions; and though we have not been able to discover all the links of this chain, these will probably, as our knowledge of nature increases, come more into view, and we shall then be able to reconcile many circumstances which we cannot at present comprehend.

With respect to the varieties that take place in the number and degree of the external senses, as possessed by the various classes of animals, we may refer the reader to what has been said on that subject in the first chapter of the comparative part of the article ANATOMY.

63 Duration of life.

The duration of life is exceedingly various. We know that there are animals which live but a few hours, as the insects called *ephemeræ*; and that others, as the *elephant*, the *raven*, and the *pike*, may exist for a century. The term of life allotted to plants is also various; some live only for a year, and are hence called *annual* plants; others exist for two years, and are called *biennial* plants; while a few surpass in longevity any thing with which we are acquainted in animated nature. Thus, the *oak* is said to require 100 years, in order to acquire its full maturity; to retain its perfect vigour for the like term, and to complete at least a third century before it entirely decays. The *chesnut* is a still more remarkable instance of vegetable longevity. The account of the gigantic chesnut on Mount Ætna, given by

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by Brydone and other travellers, which has exifted for many centuries, muft be familiar to moft of our readers. We have hitherto confidered life as difplayed in the exercife of functions; but it may exift independently of this exercife, or it may lie dormant for a confiderable time, till called into action by particular circumftances. Every one knows how long a feed or an egg, when excluded from heat, air, and moifture, will retain the faculty of producing a plant or an animal. The only proof we have, that this faculty ftill exifts is, that when we place the feed or the egg in circumftances favourable to the developement of the embryo which it contains, the procefs of generation goes on, till the plant or the animal is excluded. We know alfo, that after an organized being has commenced the exercife of its functions, this exercife may ceafe for a time, or at leaft become almoft imperceptible, while yet the vital power fhall remain fufceptible of reviving its activity at a future period. We then fay that the animal or vegetable is in a torpid ftate. On this part of the hiftory of life we fhall not enter at prefent, but fhall defer the confideration of it till we come to treat of fleep and death.

The above is a hafty comparative fketch of the functions exercifed by the various tribes of organized beings. It is fufficient to fhow, that there is in thefe beings a vital power which completely diftinguifhes them from brute or inorganic matter.

64 Caufe of life.

A queftion which naturally arifes in every thinking mind is, What is the effence of life, or on what does it depend? Though we profefs ourfelves unable to anfwer this queftion in a fatisfactory manner, and believe that all who have hitherto attempted to do fo, have failed in their attempts, it may be acceptable to moft of our readers to know the opinions of the moft refpectable writers on this abftrufe fubject. Thefe, therefore, we fhall briefly ftate.

65 Opinions refpecting the vital principle.

Thefe opinions have chiefly refted on the queftion, whether life be an independent, immaterial principle, or merely a phyfical or chemical modification of matter. We have already, in the hiftorical view which we have given of the progrefs of phyfiology, mentioned fome of the more remarkable doctrines refpecting the principle of life that have been delivered prior to the 18th century; we fhall here, therefore, only mention thofe which have been maintained fince that time.

66 John Hunter.

Mr John Hunter, in his valuable treatife on the blood, fuppofes the principle of vitality to exift in that fluid, or that the blood has life; and has founded this doctrine chiefly on the following proofs. Firft, It unites living parts, when it is effufed between them. Secondly, It becomes vafcular like other living parts; its temperature as it flows from the veffel, is always equal in the moft oppofite temperature in which the body can bear expofure. Thirdly, It is capable of being acted upon by a ftimulus, as is the cafe when it coagulates. Fourth, Paralytic limbs, though deprived of motion and fenfation, are yet nourifhed and preferved alive by the blood circulating through them.

Mr Hunter's idea of the vitality of the blood is merely the revival of one of the oldeft phyfiological doctrines on record; namely, that delivered to the Ifraelites by Mofes, that in the blood is the life of an animal.

67 Goodwin.

Dr Goodwin, in his work on the connection of life with refpiration, is of opinion, that the heart is the great feat of the principle of life in all the more perfect animals; and that the contractions of the heart with the ordinary ftimulus is the only mark of the prefence of this principle; that when the heart contracts under fuch circumftances, the body is alive; when not, it is dead. Life he therefore defines to be the faculty of propelling the fluids through the circulatory fyftem. According to him, the external concomitant circumftances which operate upon the body in health are heat and refpiration, which excite the vital principle to action; and whenever the functions of an animal are fuddenly fufpended, and the body puts on the appearance of death, it is always in our power to determine whether it be really dead, by reftoring the temperature, and by inflating the lungs with proper air. He is of opinion, with fome others, that there are no means of determining the abfolute deprivation of the vital principle but by the prefence of putrefaction.

It has lately become fafhionable to confider life as the confequence of certain chemical changes, which are going on in the body; an opinion which is chiefly fupported by Hufeland, Girtanner, and Humboldt.

68 Hufeland.

According to Hufeland, life is a chemico-animal flame, to the production of which oxygen is abfolutely neceffary, and the vital power is the moft general and powerful of all the powers of nature. He confiders it as the caufe of organization, and as poffeffing the following properties.

1. It has a greater affinity to fome organized bodies than to others; thus, the polypus may be cut in pieces without being diverted of it, and a decapitated tortoife or a frog deprived of its heart will live a long time after; whilft to the human body, or a quadruped, it would be inftant death. According to this phyfiologift, it is a general rule, that the ftronger the affinity between life and an organized being, the more imperfect is the animal; hence the zoophytes, whofe whole organization confifts in a mouth, a ftomach, and a gut, have a life exceedingly tenacious, and difficult to be deftroyed. 2. It is in greater quantity in fome organized bodies than in others. In general, cold-blooded animals live longer than thofe with warm blood. 3. It frees bodies from the chemical laws of inanimate matter, and transfers the component parts of a body from the phyfical or chemical to the organic or living world. 4. It prevents putrefaction, for no organized body can putrefy unlefs deprived of life.

69 Humboldt.

Humboldt is of opinion, that the degree of vitality depends upon the reciprocal balance of the chemical affinities of all the elementary parts of which the animal body is compofed.

70 Cuvier.

Some phyfiologifts of the prefent day deny the exiftence of the vital principle altogether. "The idea of life, (fays Cuvier), is one of thofe general and obfcure ideas produced in us by obferving a certain feries of phenomena, poffeffing mutual relations, and fucceeding each other in a conftant order. We know not indeed the nature of the link that unites thefe phenomena, but we are fenfible that a connection muft exift; and this conviction is fufficient to induce us to give it a name, which the vulgar are apt to regard as the fign of a particular principle, though in fact that name can only indicate the totality of the phenomena which have occafioned its formation."

71 Ferriar.

Dr Ferriar, in his obfervations concerning the vital principle, thinks, that fome direct arguments may be brought

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brought against the general supposition of an independent living principle. These arguments he divides into two kinds, viz. refutations of the general proofs offered in support of the vital principle; and instances of the direct influence of the mind and brain over what is termed the independent living principle. The great proofs for the support of a vital principle are, the contraction of muscles separated from the body on the application of stimulants; the performance of the vital and involuntary motions without any exertion or even consciousness of the mind, and the birth of full-grown fœtuses destitute of a brain. In all these cases, something is alleged to operate, independently of the mind, in producing muscular motion.

Dr Ferriar, in answer to the first argument drawn from the contraction of separated muscles, affirms, it may be said, 1st, That the power of contraction, in a separate muscle, is lost before putrefaction takes place, i. e. before the destruction of its texture; but if its vitality depended on its texture, this ought not to happen. 2dly, The power of contraction, in a separated muscle, is strongest upon its first separation, and becomes weaker by degrees; therefore, the contracting power seems to have been derived from some source from which it is detached by the excision of the part. 3dly, Irritation of the *medulla oblongata*, or of the nerves supplying particular muscles, occasions stronger contractions than irritation of the muscles themselves; and Dr Whytt furnishes an experiment on a frog, directly proving, that the action of separated muscles depends upon the nervous energy. 4thly, Dr Haller himself is obliged to make on this subject a concession sufficient to destroy his favourite hypothesis of the *vis insita*. 5thly, When a paralytic limb is convulsed by the electric shock, the motion never takes place without the patient's consciousness. In this case there is no distinction between the vital principle, and that exertion which in voluntary motion is always attributed to the mind. See Chap. iii.

In answer to the second argument, in favour of a vital principle, drawn from the performances of the vital and other involuntary motions, Dr Ferriar contents himself with only observing, that, allowing the organs of those motions to be supplied with nervous energy, their motions may be very well accounted for by the stimulus of their contained fluids.

The force of the third argument, drawn from the want of a brain in full-grown fœtuses, is taken off by Dr Whytt, who remarks, that as the heart is sometimes wanting in full-grown fœtuses, the argument would equally prove, that the heart is not necessary for the continuance of circulation, as that the brain is not necessary to the support of the system. Accordingly, fœtuses born without a brain do not, in general, survive birth.

Besides the general supposition of an independent living principle, an inference has been drawn from facts, of a nervous energy independent of the brain. By this term is meant, that condition derived from the brain to different parts of the body, by means of which they become capable of motion. To show, by direct proof, that there is no independent vital principle, Dr Ferriar observes, 1. That it is justly urged by Dr Monro against the doctrine of the *vis insita*, that there is too much design in the actions of different muscles, affected by different *stimuli*, to be the effect of mere mechanism. Thus, when the hand or foot is burnt, or otherwise suddenly injured, the muscles on the part immediately stimulated are not thrown into action, nor the muscles on the side irritated, but their antagonists contract immediately, and strongly. Now, if the instantaneous action be in this case chiefly produced by an effort of the mind, the supposition of a distinct vital principle is superfluous: if it be said to be produced by a living power independent of the mind, then there must be a rational power in the body independent of the mind, which is absurd. 2. The state of the vital and involuntary motions is considerably affected by the state of the mind, which equally disproves the existence of a separate vital principle, and proves the dependence of the nervous energy upon the brain. 3. Madness, it is well known, is frequently produced by causes purely mental, and in persons apparently in good health; and, as the patient's sensibility to very powerful stimuli is much diminished in maniacal cases, they afford another proof of the subordination of the nervous energy. 4. It has been observed, that in paralytic cases, motion is frequently destroyed, while sense remains. As the cause of palsy almost always resides in the brain, this fact appears equally inexplicable on the opinion of a distinct living principle, or of a nervous energy, independent of the brain. 5. When nerves are regenerated, after being cut through, sensation and voluntary motion are not always restored to the parts beneath the division: the restoration was never made in Dr Monro's experiments. But, on the supposition of a distinct nervous power, the nerve, after its re-union, ought to resume all its offices. 6. Dr Whytt asserts, that when the spinal marrow of a frog is destroyed, after decollation, no contraction can be excited in the limbs, by cutting or tearing the muscles. Such are the facts and arguments which Dr Ferriar brings against the opinion of a distinct living principle; and he thinks, that their investigation appears to lead us back to the brain as the source of sensibility and irritability.

72 Rush.

In the life of Dr John Brown, we have given an account of the doctrine, of life being a forced state. This doctrine appears to have been first delivered by Dr Cullen, though he afterwards retracted it. Of late Dr Rush of Philadelphia, in his *Lectures on animal life*, has advanced many arguments in favour of this doctrine. He includes, in animal life, three properties as applied to the human body, viz. *motion*, *sensation*, and *thought*; and these, when united, compose perfect life. It may exist without thought or sensation; but neither sensation nor thought can exist without motion. He affirms, that the lowest degree of life exists even in the absence of motion. He first considers animal life as it appears in the waking and sleeping state, in a healthy adult; and afterwards inquires into the modification of its causes in the fœtal, infant, youthful and middle states of life, in certain diseases, in different states of society, and in different animals, and lays down the following propositions:

1. Every part of the human body, the nails and hair excepted, is endued with sensibility or excitability, or with both.

2. The whole body is so formed and connected, that impressions made in the healthy state upon one part excite

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excite motion or ſenſation, or both, in every other part of the body.

3. Life is the effect of certain ſtimuli acting upon the ſenſibility and excitability, which are extended in different degrees to every external and internal part of the body; and theſe ſtimuli are as neceſſary to its exiſtence as air is to flame.

He continues to obſerve, that the action of the brain, the diaſtole and ſyſtole of the heart, the pulſation of the arteries, the contraction of the muſcles, the periſtaltic motion of the bowels, the abſorbing power of the lymphatics, ſecretion, excretion, hearing, ſeeing, ſmelling, taſte, and the ſenſe of touch, even *thought* itſelf, are all the effects of ſtimuli acting upon the organs of ſenſe and motion.

Theſe have been divided into external and internal.

1. The external are light, ſound, colours, air, heat, exerciſe, and the pleaſures of the ſenſes.

2. The internal ſtimuli are food, drinks, chyle, blood, tenſion of the glands which contain ſecreted liquors, and the exerciſe of the faculties of the mind.

Life, therefore, (according to the hypotheſis of Ruſh) even thought itſelf, is merely a quality reſiding in the component parts of a material ſyſtem, dependent upon a peculiar organization, by which it is enabled to act, or in ſome ways to move on being ſtimulated or excited. Hence life can never be inherent in a ſimple uncompounded ſubſtance, nor in a particle of animal matter; and if the ſtimulus be withheld from a living ſyſtem beyond a given time, all motion, ſenſation, and thought, muſt neceſſarily be extinguiſhed.

73 Vital principle ſuppoſed by ſome to be diviſible.

Inſtead of one vital principle, ſome phyſiologiſts have ſuppoſed the exiſtence of ſeveral in the ſame body; and from the phenomena that take place in ſome organized beings, as the reunion of parts that had been ſeparated, the reproduction of others that have been loſt, and the ſeparate exiſtence of the divided parts of ſome worms and zoophytes, it was formerly the opinion of a celebrated lecturer on anatomy, that the vital principle was really divided. From more conſiderate and extenſive inquiry, however, he is now of opinion, that the irritability on which theſe phenomena depend, is never the direct or immediate operation of the vital principle, but only the conſequence of its operation; and in no caſe excluſively the conſequence, but the conſequence likewiſe of other operations proceeding from a number of different cauſes; and hence it is that a vital principle may often exiſt where it cannot operate in a ſenſible manner, from the want of auxiliaries; and hence it is, likewiſe, that its effects may often be continued, at leaſt for a while after its departure.

With regard to the portions of plants and polypi that continue to live in a ſeparate ſtate, aſſume the form of their reſpective ſpecies, and propagate their kind, they will be found, on a cloſe examination, to have been originally complete ſyſtems; many of the plants and many of the polypi that were uſually conſidered as ſimple individuals, not conſtituting one animated ſyſtem, but rather a congeries of animated ſyſtems,—a congeries, too, which after all is nothing more than a ſpecies of ſociety, where animated beings are aſſociated together for mutual protection; ſuch as we ſee among men in a city; among bees in their cells, which, in point of form, are ſimilar to plants †.

† *Barclay on Muſcular Motions*, p. 265.

Of Senſation.

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74 Neceſſity of ſenſibility to organized beings.

As all living beings are ſo related to each other, and to the inanimate objects of nature, as to be capable of deriving benefit, or receiving injuries, from the one or from the other; it ſeems neceſſary that they ſhould poſſeſs the faculty of perceiving the proximity of the beneficial or injurious object, that they may avail themſelves of the benefit which it holds out, or avoid the danger which it threatens. Accordingly, we find that all organized beings enjoy in ſome degree the capacity of *receiving impreſſions*, which we think is proved by the motions which take place in them when affected by external agents. When a plant expands its flowers to the ſun, or turns, as it were, its back to the blaſt; when it ſtretches out the fibres of its roots to imbibe the diſtant moiſture, or directs its branches to the only chink by which it can receive the light of day; we think theſe motions are the conſequence of that capacity of *receiving impreſſions*, or of being rouzed to action by *ſtimuli*; we think that this may be conceded, without having recourſe to the influence of mind, or even the medium of a nervous ſyſtem; we do not believe that the graſs we cruſh beneath our feet is ſenſible of pain, nor do we ſuppoſe with the poet, that

> —— " E'en the poor beetle that we tread on,
> In mortal ſufferance feels a pang as great
> As when a giant dies"——

but we are of opinion, that even in the loweſt tribes there is a degree of that faculty, which in the higher orders of animals we call *ſenſibility*, and which we ſhall here, after a lecturer on the animal economy in London, denominate *ſenſitivity*. This inferior degree of the ſenſitive faculty we ſhall ſuppoſe to be poſſeſſed by plants, zoophytes, and animalcules, or thoſe organized beings in which we can perceive no marks of a nervous ſyſtem; while we ſhall confine the term *ſenſibility* to all other claſſes of animals. 75 Senſituvity.

Theſe faculties we conſider as qualities of living *bodies*, while we regard ſenſation, like perception, as a quality of *mind*. We leave it to the metaphyſician to mark the line of diſtinction between ſenſibility and ſenſation, and to ſhow how the one ariſes from the other. See Metaphysics, Part I. chap. 1.

76 Nervous ſyſtem.

The organs of ſenſation conſiſt of the brain properly ſo called, the cerebellum, the medulla oblongata, the ſpinal marrow, the nerves, and ganglia; together forming what is called the *nervous ſyſtem*. Theſe parts in the human body have been deſcribed under Anatomy. For an account of theſe organs in the inferior animals, we muſt refer to the lectures of Cuvier, vol. ii. or the Comparative Anatomy of Blumenbach.

In reſpect of *ſenſibility* the animal is only paſſive; but when *ſenſation* is produced, he becomes active, in as much as the organs of the external ſenſes are then brought into action. It is by means of theſe ſenſes that the animal receives intelligence from without. We ſhall therefore examine theſe before we mention the phenomena of ſenſation in general.

1. *Of Feeling.*

The moſt general of all the ſenſes, and the moſt widely 77 Feeling.

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ly diffuſed over the body of an animal is that of touch or feeling. Animals that poſſeſs ſcarcely any other ſenſe ſeem always to have that of *touch*. It is doubtleſs by this that *polypi*, *actiniæ*, and other water animals, perceive the approach of their prey, or are warned of impending danger, from the agitation of the water that is communicated to their bodies. Indeed ſo general is this ſenſe, that ſome phyſiologiſts think we may reduce all others to it as a genus; and ſuppoſe that *ſmelling*, *taſting*, *hearing*, and *ſeeing*, are only ſpecies of *feeling*. This reference is not uncommon in ordinary ſpeech, as it is not unuſual to talk of *feeling* a *ſmell*.

78 Uſe.

By *touch*, taken in its ordinary limited ſenſe, we perceive the more ſtriking external qualities of bodies, as *figure*, *hardneſs*, *ſoftneſs*, *roughneſs*, *ſmoothneſs*, *moiſture*, *dryneſs*, *heat*, *cold*; of all which, except figure, we could ſcarcely form any idea by the other ſenſes. There is probably no ſenſe that can ſo well ſupply the place of others as that of *touch*; and it is particularly acute in thoſe who have loſt their ſight or hearing. See the article Blind, eſpecially the Appendix.

79 Organs.

The organs of touch are the ſkin and its productions, or rather the nervous papillæ (ſee Anatomy, N° 76.) that form ſo large a part of the true ſkin. As many animals, however, have the body ſo enveloped in a ſcaly, ſhelly, or hairy covering, as to prevent the actual contact of the body by external objects, there are other organs that ſeem deſtined to fulfil this office. In man, the points of the fingers and the lips are the moſt delicate feeling organs; in many quadrupeds too, the lips ſeem to poſſeſs an exquiſite ſenſibility, and in ſome, as the *rhinoceros*, the upper lip is lengthened out as if to ſerve the purpoſe of a hand. The prolonged ſnouts of the *tapir*, the *ſhrew*, the *mole*, and the *hog*, ſeem to anſwer the ſame purpoſe; and the exquiſite ſenſibility and flexibility of the trunk of the elephant is well known to fit that organ for almoſt all the purpoſes to which the human hand can be applied. The tail, in ſome ſpecies of *monkey*, *oppoſum* and *ant-eater*, and in ſome reptiles, ſeems to poſſeſs a high degree of ſenſibility. In ſome animals, as the *cat*, the whiſkers are employed as organs of *feeling*, as we know that theſe are erected when the animal is paſſing through a narrow hole. Several ſpecies of fiſhes have *cirri* and *tentacula*, which they ſeem to uſe as fingers in aſcertaining the approach of their prey; and in inſects, the *antennæ* and the *palpi* are evidently organs of feeling, as are the arms, the tufts, and tentacula of *ſea-ſtars*, *ſea-urchins*, *actiniæ*, *meduſæ*, and many zoophytes.

80 Nature of touch.

Moſt of the actions of external bodies on the ſurface of the animal body, are merely mechanical, though the ſenſations which they communicate may often be the effects of a chemical change in ſome of the feeling organs, and this change can be produced only in conſequence of the power of ſimple preſſure, to form or deſtroy ſome of the combinations that take place in the animal ſyſtem. The ſenſations which appear moſt evidently to ariſe from a chemical change in the organs, are thoſe that give notice of a change of temperature. When a body that has a temperature below that of the animal, comes in contact with the ſurface of this latter, we know that it abſtracts from that ſurface a part of its caloric, as by the contact it gradually acquires the temperature of the animal; unleſs, indeed, it be ſo large and ſo cold as altogether to deſtroy life. As, however, the reſiſtance which the animal body gives to a too great change of temperature, generally confines this change to the ſurface of the body; there muſt be ſomething more than a mechanical or a chemical action, or the ſenſe of feeling muſt depend chiefly on the vital principle.

81 Univerſality of feeling.

As the ſenſe of feeling, from its general diffuſion, may be conſidered as the moſt eſſential of all the ſenſes; its degrees of perfection have conſiderable influence on the nature of different animals.

Of all *vertebral* animals, man ſeems to poſſeſs this ſenſe in the moſt perfect degree; but among the *invertebral* animals, the touch ſeems to improve as the other ſenſes degenerate; and thoſe animals which appear to have no other ſenſe, poſſeſs this in ſo exquiſite a degree that they ſeem to feel even the light.

Dr Darwin thinks it probable, that the animal body is furniſhed with a diſtinct ſet of nerves for the ſenſation of *heat* and *cold*. We do not ſee the neceſſity of this, as we think that this ſenſation is very naturally reducible to that of *feeling*.

82 Senſibility of the animal body.

To this head naturally belongs the conſideration of what parts of the human body poſſeſs ſenſibility, and what are inſenſible. This diſcuſſion is curious, and ſome time ago exerciſed the ingenuity of two very able phyſiologiſts, Haller and Whytt; between whom it gave riſe to a long and warm diſpute. We cannot pretend to enter into the merits of this controverſy, for an account of which we refer our readers to Dr Whytt's *Phyſiological Eſſays*, and to the *Principes de Phyſiologie* of Dumas, tom. ii. part. iii. ſect. 1. chap. 1.

The general reſult ſeems to be, that many parts will appear ſenſible or inſenſible, according to the nature of the ſtimuli applied to them, and that many of thoſe parts which in their natural and healthy ſtate appear inſuſceptible of pain, are when inflamed or otherwiſe altered by diſeaſes, highly ſenſible; and that the brain, which is conſidered as the centre of all ſenſation, and the puncture or laceration of which is attended with moſt diſtreſſing ſymptoms in other parts, is to ordinary ſtimuli as inſenſible as the cuticle or the nails. See alſo on this ſubject, Bichat "Anatomie Generale," tom. i. p. 161.—167.

The principal morbid affections of this ſenſe, are *pain*, *itching*, and *want of feeling*; for an account of which ſee Medicine, N° 77. The functions of the ſkin, independently of its uſe as an organ of touch, will be conſidered in two of our ſucceeding chapters.

2. *Of Taſting.*

83 Taſting.

This ſenſe is the moſt nearly allied to feeling of any of the other ſenſes, and therefore very properly comes under our conſideration after that ſenſe.

84 Organs.

The principal organ of taſte is the tongue, eſpecially at its upper ſurface, point, and edges; but it alſo extends to the lips, the palate, and the *velum pendulum palati*. The tongue is not abſolutely neceſſary to taſte, as appears from a caſe mentioned by Juſſieu, of a perſon who had only a fleſhy tubercle in place of a tongue, and yet poſſeſſed the ſenſe ſufficiently perfect.

85 Different organs variouſly affected.

The ſeveral parts of the organs of taſte are not equally ſenſible to every ſapid body; the tongue ſeems to be more particularly affected by ſaline and ſaccharine ſubſtances, chiefly, however, at its upper ſurface; the lips are ſaid to be

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be most susceptible of the taste of *hellebore*, the palate of *belladonna*, and the gullet of *wormwood*. The *momordica elaterium* is said chiefly to affect the back of the tongue, and *colocynth* its middle.

86 On what the perfection of taste depends.

The greater or less perfection of this sense depends much on the softness, flexibility, and moistness of these parts. As man seems to possess these qualifications in a more eminent degree than most other animals, so, in the natural unsophisticated state of the tongue, he probably enjoys the benefit of taste much more highly than they. Such is the case with all young children, and with the peasant, whose simple fare appears to be eaten with a much greater relish than all the delicacies of the voluptuary, who must have recourse to various stimuli to enable him to derive gratification from even the daintiest viands (A).

Taste seems to be more exquisite when the sapid body is strongly pressed between the tongue and the palate. Taste is also rendered more acute when the tongue is stimulated by various condiments, as *pepper*, *mustard*, which even, when not taken in such quantity as to be very perceptible themselves, evidently increase the relish of the dishes which they season. Much also depends on the nature and state of the bodies that are applied to the organs of taste. These must, in the first place, be either fluid, or capable of solution in the saliva. They must also possess some saline or acrid quality, to render them capable of acting on the nervous *papillæ*. It was formerly supposed, that saline bodies alone possessed the power of affecting the organs of taste; and it was conceived by Bellini, that the different flavours of saline bodies depended on the figure of their crystalline particles. M. Dumas has taken considerable pains, and has advanced several arguments, to show the absurdity of this hypothesis; and we think has treated it with more seriousness than it deserves. That the different sensations which sapid bodies excite in our organs of taste, depend chiefly on a difference in their chemical nature, must, we think, be allowed, and some have gone so far as to suppose, that the sensation depends on some chemical affinity between the sapid body and the nervous fluid.

87 Modifications of taste.

The impression which sapid bodies make on the organs of taste is modified by age, sex, temperament, and habit. We know that children are particularly pleased with sweet things, while high seasoned dishes and vinous liquors are more palatable to people of a more advanced age. Women, from various causes, especially during pregnancy, and when labouring under hysteric affections, have often very singular tastes. People of a warm and a mobile constitution are often affected by flavours that are almost insensible to others; and custom will render palatable many substances, which, when first tasted, are rejected with disgust.

88 Uses of taste.

Besides the gratification afforded to animals by the sense of taste, this is supposed to afford one of the principal means of distinguishing between wholesome and deleterious substances. Indeed, with respect to the inferior animals, this discriminating sense is seldom known to fail, and in this instance, they are superior to man, who is often deceived. There are many poisonous herbs, the fruits or roots of which have a taste not unpleasant, but which cannot be eaten with impunity.

On the morbid affections of taste, see MEDICINE, N° 78.

3. *Of Smelling*.

The sense of smelling, like that of taste, is nearly allied to feeling, and is one of those by which we become acquainted with the mechanical and chemical properties of external bodies. It is caused by volatile particles flying off from odorous bodies, and diffused or dissolved in the atmosphere, in union with which they enter the nostrils and affect the nerves of the smelling organs. 89 Smelling.

It is difficult to ascertain what are the essential organs of smelling. We know that in most animals which breathe through lungs or gills, there is either a nose, or there are certain holes that serve the purpose of nostrils; but in many animals there is nothing similar to these, and yet there is every reason to believe that they possess the sense of smelling in an exquisite degree. 90 Organs.

Insects discover their food at a distance. Butterflies seek their females, even when inclosed in boxes; and as they are liable to be deceived by resemblance of colour, it is evident that these insects are guided in many circumstances by the sense of smell. Thus the flesh-fly (*musca vomitoria*) lays its eggs on plants that have a fœtid smell, imagining that it places them on corrupted flesh, and the larvæ which are thus produced perish for want of their necessary food.

As the organ of smell, in all animals which respire air, is situated at the entrance of the organs of respiration, the most probable conjecture that has been proposed respecting its seat in insects, is that of Baster, since revived by several naturalists, who placed it in the mouths of the tracheæ or air tubes. Beside many other reasons that might be stated in support of this opinion, we may observe, that the internal membrane of the tracheæ appears very well calculated to perform this office, being soft and moistened, and that the insects in which the tracheæ enlarge, and form numerous or considerable vesicles, are those which seem to possess the most perfect sense of smelling. Such are all the *scarabæi*, the *bees*, *flies*, &c.

The antennæ, which other anatomists have supposed to be the seat of smelling in insects, do not appear to Cuvier to possess any of the requisites for that organ.

The *mollusca*, which respire air, may also possess this sensation at the entrance of their pulmonary vessels; but it is not necessary to search for a particular organ of this sense in them, as their whole skin appears to resemble a pituitary membrane. It is everywhere soft, fungous, and is always moistened by a great quantity of mucous matter. Finally, it is supplied with numerous nerves, which animate every point of its surface.

The

(A) It is generally supposed, that the sense of tasting is more acute in some of the inferior animals than in man; an opinion which is founded chiefly on the greater size and number of the *papillæ* of the tongue in those animals. It is scarcely possible to decide this point; but we should conceive, from the infinite variety of substances that are occasionally subjected to the human palate, and from the extreme delicacy of taste displayed by some individuals, that man has the advantage of his brute neighbours in this sense.

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The worms and soft zoophytes, and all the polypes, are probably in the same situation. It cannot be doubted but that these animals enjoy the sense of smell. It is chiefly by it that they discover their food, particularly the species that have no eyes. Aristotle remarked, that certain herbs, which have a strong odour, were avoided by *cuttle-fishes* and the *octopus*.

91 Nature of odours little understood.

Of all the substances which affect our organs of sensation, odours are the least understood, though the impressions which they make on the animal body appear to be most powerful and extensive. Some bodies are always odorous, because the whole or a part of their substance, being volatile, it is constantly flying off: others become odorous, only under certain circumstances; as when a body containing a volatile principle in its composition is decomposed by another that has a less affinity for that principle, e. gr. when *muriate of ammonia* is decomposed by quicklime.

Odours seem to be propagated in the air, much in the same manner as one fluid is diffused through another. Their motion is not direct like that of light, nor is it rapid or susceptible of reflection and refraction like light and caloric. The odorous particles of volatile bodies may enter into combination with different substances, by chemical affinity, and thus lose their original properties. In this way the effluvia of putrid meat are destroyed by fresh burnt charcoal, and the noxious exhalations from pestilential apartments are removed by the vapours of nitric or muriatic acid.

These circumstances seem to prove that each smell is occasioned by a particular substance floating in the atmosphere. There are others, however, which appear to indicate that odour is not always produced in this manner.

Several bodies yield a strong smell for a great length of time, without sustaining any sensible loss of substance; such, for example, is musk. Some odours are perceived when no evaporation can be observed, as the smell which arises from the friction of copper, that produced by the fusion of a great number of bodies, and even by the melting of common ice. In other cases, real evaporations produce no sensible odour; this may be remarked on the disengagement of several gases, and even on the ordinary evaporation of water. Perhaps these phenomena prove only that the force of sensation is not proportional to the quantity of the substance by which it is excited, but that it depends on the nature and degree of the affinity of that substance with the nervous fluid.* The action of the greater part of odorous substances on the nervous system, is rendered manifest by a number of other effects besides the sensation of smell; some produce faintings, others giddiness, or even convulsions. Some, on the contrary, serve to remove these disorders: indeed the greater part of medicines act in general rather by their volatile and odorous parts, than by their other principles; and afford new proofs of the influence exercised in the animal economy by the gaseous and impalpable substances, the greater part of which are doubtless still unknown to us.

* *Cuvier.*

We know not whether odours have a peculiar vehicle, besides the matter of heat, which is common to them all in their quality of vapours or elastic fluids. We cannot explain why odours are agreeable or disagreeable to us, nor why those that are disgusting to us appear pleasing to other animals, and *vice versa*. Though man and other animals are generally pleased with the odour of those substances which serve them as food; yet when their appetite is satisfied, this odour often becomes displeasing to them. On the contrary, some animals appear to have a passionate fondness for strong smelling substances which seem altogether useless to them. Thus cats are extremely fond of *cat-mint*, and the fresh roots of valerian. In general, those odours which are most disagreeable indicate that the substances from which they proceed are injurious. Thus venomous plants, putrid flesh, and poisonous minerals, have commonly an unpleasant odour. This rule, however, is not universal; and the sense of smell, like that of taste, is not an unerring guide to man, whatever it may be to other animals.

It appears that the effluvia of odorous bodies are capable of diffusing themselves through water as well as air; for when these substances are thrown into water as bait for fish, we find that these animals are attracted by the smell from a considerable distance.

92 Comparative physiology of smelling.

The comparative physiology of this sense is very curious, though we cannot explain the reason of the differences that we find to take place in the various tribes of animals. Man in a state of civilized society, where he may have recourse to a great variety of means by which to distinguish the properties of bodies, has less occasion for acuteness of smell; but we know that savages are in that respect greatly his superiors. Their smell is so acute, that like a blood-hound, they can scent their enemy to a great distance, and pursue his track with almost certain success. Among birds and beasts of prey we also find that acuteness of smell is a very general property. Hyænas, wolves, vultures, and ravens, can distinguish the putrid carcases on which they feed many miles off; and it is asserted by naturalists, that jackalls hunt in packs, and follow their game like hounds by the scent. There is a curious diversity in this respect among birds, some having this sense very acute, others very blunt. We are told by Gattoni*, that the cock is scarcely affected with the smell of ammonia or hartshorn, while the duck is said to avoid all powerful odours whether agreeable or otherwise. We are not sufficiently acquainted with the nature of the olfactory membrane, nor with that of the nerves distributed to it, to enable us to form an opinion respecting the degree and the kind of sensations they procure to different animals. It may, however, be at first sight presumed, that all things in other respects being equal, the animals in which the olfactory membrane is most extensive, enjoy the sensation of smell most exquisitely; and experience confirms this conjecture. It would be curious to learn why the animals which possess the sense of smell in the highest degree, are precisely those which feed on the most fetid substances, as we observe in *dogs* which eat carrion.

* *Scarpa de Auditu et Olfactu.*

4. *Of Hearing.*

93 Hearing.

The sense of *hearing* is more important than any which we have yet noticed, but it appears to be less generally diffused.

By means of it we become acquainted with those properties of bodies which fit them for making sensible impressions on the air, as hardness, elasticity, &c.; and these impressions on the air, when communicated to the organs of hearing, convey to our mind the ideas of sound.

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By this ſenſe we derive two of the higheſt gratifications that we are capable of enjoying, viz. the pleaſures of converſation and of muſic; and in this way moſt animals hold intercourſe with each other.

94 Organs.

The organs of hearing differ exceedingly in the various claſſes of animals. The *human* ear and its appendages have been deſcribed in ANATOMY, Part I. chap. vi. ſect. 4.; and for an account of theſe organs in other animals, we muſt refer to *Cuvier's Lectures*, vol. ii. or the *Comparative Anatomy* of Blumenbach, chap. xx. Red-blooded animals without exception have evident auditory organs; and analogous parts are found in many of the white-blooded. In a great number of the inferior claſſes, however, no ſuch parts have been aſcertained, though it is certain that many of them do really hear. In all thoſe in which theſe organs have been detected, there is always found a *gelatinous pulp*, covered with a fine, elaſtic membrane, and in this *pulp* the ramifications of the auditory nerve are loſt. It is therefore, highly probable that the *ſeat* of hearing reſides in the minute nervous fibres that are diſtributed through the pulp, and that this latter is the medium by which ſounds are communicated from the percuſſed air. We may form a tolerably juſt idea of the manner in which this pulpy ſubſtance is connected with the external movements that are the cauſe of ſound; for this quivering jelly will readily receive the concuſſions of the air or water that are tranſmitted to it from the vibrations of ſonorous bodies, and communicate them to the nervous filaments. Thus far only can we trace the motion of ſound; but the ſteps by which this motion is carried on till the perception of ſound is produced in the mind, are equally unknown to the anatomiſt and the metaphyſician.

95 Varieties of ſound.

The philoſophy of ſound has already been treated of under ACOUSTICS. It is neceſſary here to remark only, that the qualities of ſound may be diſtinguiſhed into *force*, depending on the extent of the vibrations of the body from which the ſound proceeds; *tone*, depending on the velocity of the vibrations; *reſonance*, ariſing from the intimate compoſition of the ſonorous body; *ſimple modulation of voice*, and *articulations*.

96 Comparative phyſiology of hearing.

The human ear can diſtinguiſh all theſe different qualities with relation to one ſound; this diſtinction is made with wonderful accuracy, by perſons who frequently exerciſe that faculty, and particularly by profeſſional muſicians. The other mammalia exhibit proofs that they are capable of diſtinguiſhing the qualities of ſound which relate to ſpeech, that is to ſay, *ſimple vocal modulations* and *articulations*; for we may obſerve daily, that they remember the ſound and ſignification of ſeveral words. Some are ſtrongly affected by certain ſounds. Acute tones produce a painful ſenſation in *dogs*, and we alſo obſerve that theſe animals are terrified by violent noiſes; they therefore diſtinguiſh theſe two properties. Birds have a feeling, no leſs exquiſite, of *voice, tone, articulation*, and even *reſonance*, ſince they learn to ſing with great correctneſs; and when their vocal organs permit them, can completely counterfeit the human ſpeech, with all the modifications practiſed by the individuals they imitate.

As to cold-blooded animals, it is well known that ſeveral of them call each other by certain ſounds, and that others, which are incapable of producing ſounds, can at leaſt underſtand them, as *carps*, which appear when the noiſe of a bell indicates to them that they are to be fed, &c.; but we know not what qualities of ſound they diſtinguiſh, and how far, in this reſpect, the delicacy of their ſenſe of hearing extends *.

* *Cuvier Comp. Anat.* vol. ii. ſect. 13.

For the morbid affections of hearing, ſee MEDICINE, N° 80.

5. *Of Seeing.*

97 Seeing.

As we aſcend from the ſimpler to the more complex ſenſes, we find a greater ſcope for deſcription and obſervation; but we alſo find our phyſiological difficulties increaſed. The ſenſe of touch being the moſt ſimple of all the ſenſes, requires but a ſimple organization, and is the moſt widely diffuſed; that of viſion, on the other hand, is the moſt complex, and requires for its mechaniſm, a more elaborate ſet of organs. There is not, in the whole animal ſtructure, a more curious and admirable organ than the eye, whether we contemplate it in its moſt perfect ſtate in the human body, or in its moſt ſimple conformation, as it appears in the horn of a ſnail.

98 Organs.

The anatomy of the human eye has been ſufficiently deſcribed in the article ANATOMY, Part I. chap. vi. ſect. 5.; and if our readers deſire a fuller account of this organ, we may refer them to the elegant work of Profeſſor Soëmmering. The ſtructure of the eye in the inferior animals is well deſcribed in Cuvier's twelfth lecture, and in Blumenbach's Comparative Anatomy, chap. xvi. We ſhall extract from the former a deſcription of the eyes of inſects and cruſtaceous animals, as being among the moſt curious and leaſt known ſubjects of comparative anatomy.

" The ſtructure of the eye of inſects is ſo very different from that of other animals, even the molluſca, that it would be difficult to believe it an organ of ſight, had not experiments, purpoſely made, demonſtrated its uſe. If we cut out, or cover with opaque matter, the eye of the *dragon-fly*, it will ſtrike againſt walls in its flight. If we cover the compound eyes of the *waſp*, it aſcends perpendicularly in the air, until it completely diſappears; if we cover its ſimple eyes only, it will not attempt to fly, but will remain perfectly immoveable.

" The ſurface of a compound eye, when viewed by the microſcope, exhibits an innumerable multitude of hexagonal facets, ſlightly convex, and ſeparated from one another by ſmall furrows, which frequently contain fine hairs, more or leſs long.

" Theſe facets form altogether a hard and elaſtic membrane, which, when freed of the ſubſtances that adhere to it poſteriorly, is very tranſparent.

" Each of theſe ſmall ſurfaces may be conſidered either as a cornea, or a cryſtalline; for it is convex externally, and concave internally, but thicker in the middle than at the edges, it is alſo the only tranſparent part in this ſingular eye.

" Immediately behind this tranſparent membrane there is an opaque ſubſtance, which varies greatly as to colour in different ſpecies, and which ſometimes forms, even in the ſame eye, ſpots or bands of different colours. Its conſiſtence is the ſame as that of the pigment of the *choroides*; it entirely covers the poſterior part of the tranſparent facets, without leaving any aperture for the paſſage of the light.

" Behind this pigment we find ſome very ſhort white filaments, in the form of hexagonal priſms, ſituated cloſe to each other, like the ſtones of a pavement, and

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precifely equal in number to the facets of the cornea; each penetrates into the hollow part of one of thefe facets, and is feparated from it only by the pigment mentioned above. If thefe filaments are nervous, as in my opinion they appear to be, we may confider each as the retina of the furface behind which it is placed: but it will always remain to be explained, how the light can act on this retina, through a coat of opaque pigment.

"This multitude of filaments, perpendicular to the cornea, have behind them a membrane which ferves them all as a bafe, and which is confequently nearly parallel to the cornea; this membrane is very fine, and of a blackifh colour, which is not caufed by a pigment, but extends to its moft intimate texture; we obferve in it very fine whitifh lines, which are tracheæ, and and will produce ftill finer branches, that penetrate between the hexagonal filaments, as far as the cornea. By analogy, we may name this membrane the *choroides*.

"A thin expanfion of the optic nerve is applied to the pofterior part of the choroides. This is a real nervous membrane, perfectly fimilar to the retina of red-blooded animals; it appears that the white filaments, which form the particular retinæ of the different ocular furfaces, are productions of this general retina, which perforates the membrane I have named choroides, by a multitude of fmall and almoft imperceptible holes.

"To obtain a diftinct view of all thefe parts, it is neceffary to cut off the head of an infect that has the eyes large, and diffect it pofteriorly; each part will then be removed in an order the reverfe of that in which I have defcribed them.

"In the cray fifhes, in general, the eye is fituated on a moveable tubercle. The extremity, which is rounded on every fide, and fometimes elongated into a cone, when viewed by a glafs, prefents the fame furfaces as the eyes of infects. When we cut this tubercle longitudinally, we obferve that the optic nerve paffes through it in a cylindrical canal, which occupies the place of its axis. Arrived at the centre of the concavity of the eye, it forms a fmall button, which detaches very fine filaments in every direction; at a certain diftance thefe filaments meet the choroides, which is nearly concentrical with the cornea, and covers the fpherical brufh of the extremity of the nerve, like a hood. All the diftance between the choroides and the cornea is occupied, as in infects, by white filaments, clofely arranged in a perpendicular direction to each other, and which have the extremity next the cornea alfo coated with a black pigment.

Cuvier's Lectures, vol. ii.

"Thefe filaments perforate the choroides, and are continuations of thofe produced by the button, which terminates the optic nerve."

99 Immediate feat of vifion probably the retina.

The immediate feat of vifion is ftill in difpute; but it appears to be the expanfion of the optic nerve upon the inner coat of the eye. The other parts of that organ ferve to collect, refract, abforb, and fometimes even reflect, the rays of light, according as thefe operations are required for the diftinct vifion of any particular animal. Thofe animals that feek for their prey during night, have a pupil that is very dilatable, and have very little of that dark fubftance called *pigmentum nigrum*, that lies between the retina and the choroid coat in diurnal animals. Thus, the former have their eyes better adapted to receive and to retain the feeble rays of light, and thus poffefs a great advantage over the animals which they purfue, whofe eyes are calculated for feeing beft in a ftrong light.

The fubject of vifion has been fo fully confidered under OPTICS, Part I. fect. 5. that it is unneceffary for us to give any detailed account of it here. We fhall therefore merely enumerate the principal phenomena. 100

Phenomena of vifion.

1. The rays of light proceeding from luminous bodies, are collected by the cornea; varioufly refracted by the aqueous, cryftalline, and vitreous humours, till they meet in a point (in perfect vifion) in the retina, from which the fenfation conveyed to the brain, excites there the ideas of light, colour, and other qualities of extreme objects, of which the eye is capable of judging.

2. The image of the object thus pictured on the retina, is inverted, though the mind is habituated to perceive it as if it were erect.

3. There is a certain point within the eye where the retina is deficient, and here the luminous rays make no impreffion.

4. The eye is calculated to fee objects moft diftinctly at certain diftances or foci, though thefe diftances vary confiderably in different fpecies, and different individuals. A perfon of ordinary fight can read a middle-fized print moft diftinctly at the diftance of about eight inches. Thofe who require a lefs diftance are near-fighted, or *myopes*, and in them the point of divergence of rays is before the retina. Thofe who require a greater diftance are long-fighted, or *prefbyopes*; and in thefe the point of divergence is behind the retina.

5. In thofe animals that have two eyes, an image of a luminous object is formed in each, though the mind is accuftomed to unite both images into one. In ftrabifmus or fquinting, the two eyes not being fimilarly directed, do not concur in producing a fingle object.

6. Though the images of many objects are impreffed on the retina at the fame time, the mind can attend diftinctly to only one of them.

7. In perfect vifion, the pupil contracts or dilates according to the greater or lefs quantity of light that is prefent.

8. When the eye has looked fteadily for fome time on a circumfcribed fpace, of a particular colour, as a piece of red paper placed on a white ground, it perceives a border of a different colour furrounding the original fpot. This furrounding colour is called the *accidental* colour of the former, and differs according to the colour of the original fpot. In the prefent inftance it is green, or bluifh-green. The other natural colours are attended by the following accidental colours, viz. ORANGE, by *blue*, with nearly an equal proportion of *indigo*; YELLOW by *indigo*, with a mixture of *violet*; GREEN by *violet*, with a mixture of *red*; BLUE by *red*, with a mixture of *orange*; INDIGO by *yellow*, with a confiderable mixture of *orange*; and VIOLET by *green*, with a confiderable mixture of *blue* (B).

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(B) Dr Darwin, in his *Zoonomia*, vol. i. fect. 2. employs the phenomena of accidental colours to prove that the fibres

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101 Requisites for distinct vision.

The exercise of distinct vision depends chiefly on the following circumstances: 1. The perfect transparency of the cornea, and the several humours of the eye; 2. on the just proportional distance between the cornea and the crystalline lens, and on their degree of convexity; 3. on the sensibility of the retina; 4. on the degree of illumination of the visible object; 5. on the colour of the pigmentum between the choroid and the retina; and 6. on the contraction and dilatation of the pupil.

102 Action of light on the system.

The action of light on living beings is not confined to its effects in producing vision. It seems to act on the system in general as a moderate but constant stimulus. When the light of day is vivid, as in bright sunshine, the body is more active, and the mind more vigorous, than under a cloudy sky. Those climates which are frequently obscured by clouds and vapours, are notoriously the birthplaces of seriousness and gloom; and Bœotian dulness and English melancholy have long become proverbial; while on the contrary, the serene brightness of an eastern sky has been considered as peculiarly favourable to the exertions of imagination, and the flights of fancy. Mr Stuart, a famous pedestrian traveller, told Dr Rush, that during a summer which he passed in a high northern latitude, where the sun is visible for several months together, he enjoyed an uncommon share of health and spirits, which he attributed to the long continuance of the light of the sun. In a state of nature most animals retire to rest when the light fails, and few people can sleep soundly, unless light be excluded.

The stimulating effects of light are peculiarly evident on persons whose nervous system is unusually sensible; they cannot bear strong light, which not only hurts their eyes, but produces considerable agitation on their whole frame. The same effects are produced on those who have been confined in a dark prison. The countenance of these unfortunates is pale and sallow. This latter effect of the absence of light is similar to what takes place in vegetables, as we know that the colour, taste, and smell of plants depend on their being exposed to a due degree of light.

103 Absence of light supposed to favour obesity.

It has been remarked, that those animals which have been long confined in a dark situation, are universally disposed to grow fat; and this has been found to take place even in condemned criminals, in whom we would least expect it. This obesity has been attributed chiefly to the absence of light. We are disposed to think that the absence of this stimulus can have no immediate effect, but that the disposition to obesity depends rather on the indolence of the confined animals, which is favoured by the absence of light.

For an account of the principal morbid affections of vision, see MEDICINE, N° 81.

6. *Is there in some animals a sixth sense?*

104 Bats supposed to have a sixth sense.

From the experiments of Jurin and Spallanzani on the flight of bats that have been deprived of sight, (see MAMMALIA, N° 38.) it has been supposed by some that the accuracy with which these animals in their flight avoided the obstacles that were placed in their way, is owing to some additional sense which they possess. Others have conceived that the sense of hearing which appears to be very acute in the species on which these experiments were made, is sufficient to supply their want of sight. It is scarcely possible to ascertain which of these two opinions is the more probable; but the writer of this article is rather inclined to adopt the latter, from having observed that when he was walking in an unfrequented street, when it was very dark, he was enabled to avoid running against the common stairs that projected into the street, from a certain sensation that he perceived, when he approached the wall of the stair, which he cannot better describe than by saying that the air at these points appeared to be unusually still.

With respect to sensation in general, we may lay down the following laws, which are considered by Dumas as fundamental principles of this function.

1. As activity is an essential character of sensation, this cannot exist without a certain action of the organs, and must be proportioned to the degree of attention bestowed on the external objects, or ideas by which it is produced. 105 Laws of sensation.

2. A repetition of the same sensations tends to render the sensibility less acute, and less capable of receiving new impressions. By repose its energy is restored.

3. As sensibility cannot be employed on two impressions at the same time, it must hold a certain balance throughout all the organs, and it cannot be acutely excited in one part, without being proportionably diminished in another.

4. Sensibility is a relative faculty, which is not equally obedient to all kinds of excitations, but only to those which have some relation to it in the different parts of the living body.

5. It is increased and accumulated in the direct proportion to the defect or weakness of stimulus.

6. It is not proportioned to the number, arrangement, or distribution of the nerves, and its changes of increase or diminution are not susceptible of calculation.

7. It is inconstant, variable in its progress, and unconfinable *.

To these we may add the following facts respecting this function and its organs.

1. The nerves which are principally distributed to the organs of the external senses, arise from that part of the sensorium that is within the head.

2. The sensations produced in any part by the contact of external bodies, are more perfect, according as the nerves which terminate in that part arise more immediately from the common sensorium.

3. When a ligature is fastened on a nerve, the parts on which the nerve is distributed are deprived of sensation as far as depends on that nerve.

4. Compression of the brain diminishes general sensation in proportion to its intensity. Slight compression produces numbness.

5. Though sensation probably takes place only in the central parts of the sensorium, it is commonly referred to the extremities of the nerves. Thus, a gouty person who has lost his leg, will suppose that he sometimes feels

* Dumas, *Principes de Physiologie*, tom. ii. p. 151.

fibres of the retina are thrown into contraction, like those of muscles, and that some of them act as antagonists to others; as he considers the accidental as the reverse of the natural colours.

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feels the pain of the gout in the toe of the amputated limb.

6. A sympathy takes place between those parts which are supplied by branches of the same nerve. Thus, a violent scratching of the head often produces sneezing; powerful odours snuffed at the nose produce a flow of tears; the head sympathises with the stomach; the mammæ with the uterus, &c.

These are all the phenomena respecting sensation which we can at present notice; we shall mention others when we come to consider the relation between this function and those of motion, digestion, circulation, &c.

106 Internal senses belong to metaphysics.

What have been called the internal senses, as memory, imagination, and judgement, are rather qualities of the mind, than operations of the brain; and the consideration of them belongs rather to metaphysics than physiology. To that article, therefore, we refer the reader; and we shall conclude this account of the phenomena of sensation with the following comparative view of that function in the inferior animals.

107 Comparative physiology of sensation.

In all animals that have nerves, voluntary motions and direct sensations take place by the same means as in man. The differences in their motions depend partly on the intrinsic mobility of their fibres, and partly on the disposition of their muscles, and the parts to which they are attached.

The differences in their sensations depend on the number of their senses, and the perfection of the organs belonging to each sense. The animals that approach nearest to man have their senses equal in number to his. In certain species, some of these senses are even more perfect in the structure of their organs, and susceptible of more lively and delicate impressions than ours; on the contrary, in proportion as animals are removed from us, the number of their senses and the perfection of certain organs are diminished; but perhaps some animals, at the same time, possess senses of which we can form no idea.

We know not whether there are differences in the intrinsic sensibility of the nervous system of different animals, i. e. whether an equal impression made on an organ equally perfect, would affect every animal with the same force.

The animals next in order to man have, like him, spontaneous, or what we call internal, sensations. Images are excited in them at times, when they receive no immediate impression from external objects. Thus, dogs and parrots dream. We are not certain, indeed, that the more inferior animals experience similar sensations.

The passions produce effects in animals similar to those which they excite in man. Love is manifested in the same manner in all classes; fear occasions a discharge of excrements in quadrupeds and birds; it makes them tremble, and even renders insects immoveable; but the other animals afford fewer examples of these kind of phenomena than man, because they are not masters of their imagination, cannot direct it towards certain objects, and create for themselves factitious passions. We are even ignorant whether their imaginations can, like ours, be wrought up to such a pitch as to make them experience emotions of anger, desire, or fear, from simple ideas or simple recollections; and whether the real presence of the objects which cause these passions, is not always necessary to excite them in the inferior animals; we know, however, that those which approach nearest to us, the mammalia and the birds, have their sorrows. The affliction they feel on the absence or loss of a companion, friend, or benefactor, is manifested by evident signs, in the same manner as they testify their attachment without any temporary inducement.

The same animals exhibit frequent proofs of a very perfect memory; some even appear to possess a certain degree of judgement. But does any thing similar exist in the inferior classes, and particularly in the lowest? Of this we shall probably remain always ignorant.

With so much resemblance in the structure of the nervous system, in its mode of action, and in the number and structure of the principal external organs, why is there so vast a difference, as to the total result, between man and the most perfect animal?

Is this owing to a more accurate proportion in the relative perfection of the external organs, so that one does not so much surpass another? Or has the internal organ, in which are performed all the intermediate operations between the sensation received and the movement executed, that is to say, the organ of perception, memory and judgement, greater differences than we have yet observed? Or, finally, is the substance by which these processes are effected of a different nature? These, however, are not anatomical questions.

The sympathies or effects resulting from the connections of nerves with each other, and the influence of the nerves on vegetative functions, are subject to the same laws in man and the other animals *.

* *Cuvier's Lectures*, vol. ii.

108 Theory of sensation.

The theory of sensation is perhaps more imperfect than that of any other function. On this subject we can derive little light from the structure of the brain and nerves, accurately as this has been examined. Anatomy has taught us, that the principal part of these organs consists of very delicate fibres, intermixed with a medullary pulp, and incased in membranes; and that they are furnished with a great proportion of blood-vessels; but whether the seat of sensation resides in the fibrous or medullary part, we cannot ascertain.

109 Vibration.

It was formerly the opinion, that the nervous power was propagated between the brain and the external organs, by vibrations of the nerves; but as the structure of these chords, and their connection with surrounding parts, must wholly disqualify them for such vibrations, this theory has long been abandoned.

110 Nervous fluid.

Another hypothesis that has been very generally received is, that the nervous fibres are the conductors of a very subtile fluid, called the nervous fluid, the motions of which are the cause of sensation. This was the opinion of Dr Haller, (*First Lines*, chap. x.) and was strenuously maintained by Dr Cullen. We shall present our readers with the following modification of it, as given by an able disciple of Cullen.

" It is probable, (says this writer), that in each nervous fibril, an elastic fluid is inherent, forming, from the moment of animation, a part of it; differing, however, according to the state of the constitution, in power, mobility, and, perhaps, in other qualities. Of this fluid the nerves are conductors, and are surrounded in their course by non-conducting membranes, while the same membrane lines every part of the brain, and is carried into the deepest cavities, guarding with particular attention the slightest aperture. In this view sanguiferous vessels are chiefly useful in nourishing this medullary substance, and they appear to be necessary also in adapting the

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the nerves to their office; for, when the circulation is greatly increafed, the fenfibility is more acute; and when it languifhes, or is deftroyed, the nervous energy foon fhares the fame fate.

"This fluid muft neceffarily be an elaftic one; and impreffions are apparently conveyed through it by vibrations. It does not follow from hence, that the nerves vibrate like mufcular cords; or that, in every the flighteft motion, a portion is conveyed from the brain. The elafticity of the fluid is proved from the momentary continuance of the impreffion after the caufe is removed; and vibration is a term employed in many branches of philofophy as a means of communicating motion, without any diftinct application. If we touch an object with a ftick, or with a metallic rod, we perceive through it the impreffion, and, in a general way, the nature of the fubftance. The impreffion muft be conveyed by fomething; and whatever that fomething is, it may as well convey impreffions through the nerves as through the rod. But through the nerves only can it affect the brain, and produce an *idea*, or fome change in the brain, or its fluid connected with the nature of the object, and which conveys to the mind fome peculiar and difcriminated impreffion which it afterwards retains *."

* *New London Medical Dictionary*, vol. i. p. 398.

A third hypothefis, which is at prefent very fafhionable, is, that fenfation is produced by a change in the fubftance of the brain and nerves. M. Cuvier is an advocate for this doctrine, which he illuftrates in the following manner.

The nervous fyftem is fufceptible of two kinds of action; one which is confined to our fenfitive faculty, and another which affects our vital and vegetative functions only. External fenfations are produced by the impreffions of external bodies, on our fenfes; internal fenfations, by changes which take place, in the ftate of the internal parts of the body, to which the nerves are diftributed; and fpontaneous fenfations are caufed by a change in the nerves, or in the brain itfelf, without any external excitement.

Thefe circumftances, added to the phenomena arifing from the cutting or tying of nerves, fhow, that fenfation does not refide in the external organs, but nearly in the centre of the nervous fyftem, and that the external organs ferve only to receive the action of the external bodies, and to convey it to the nerves, by which it is propagated to a greater diftance. They alfo demonftrate, that this propagation is not produced by any matter or concuffion, but by a change in the ftate of the nervous fubftance. This change may arife from internal caufes, or it may be produced by external caufes, different from thofe which ufually occafion it. The nerves are not merely paffive agents, nor the conductors or refervoirs of any particular matter; but it appears, that the fubftance which produces fenfation, is liable to be confumed, or to lofe its activity by exertion.

There are phenomena which fhew that the general fufceptibility of the nerves, for receiving fenfations, may vary in confequence of caufes external to the nerves themfelves, and which can operate only by altering their fubftance. Certain medicines weaken or revive that fufceptibility;—inflammation frequently increafes it to an exceffive degree. Does this take place in confequence of an increafed fecretion of the nervous matter? The moft remarkable change that occurs in the fufceptibility of nerves, is fleep. It is not unnatural to fuppofe that this change may be occafioned by the temporary lofs of the fubftance which is effentially fenfitive. But how does it happen that fleep depends, in a certain degree, on the will? Why do we awake fuddenly, or from caufes which do not appear calculated to reftore that fubftance? Why does cold produce fleep? From thefe obfervations, may it not rather be fuppofed that this ftate is the effect of a change in the chemical nature of the nervous fubftance?

But whether the fubftance contained in the nerves is exhaufted by fenfations, or whether it merely undergoes an alteration in its chemical compofition, and becomes, as it were, neutralized, it muft remain in the nerve throughout the whole of its courfe, and leave it only at one of its extremities. It does not, however, refemble the blood in the veffels, either as to the manner in which it is retained, or in which it moves in the nerve. There is no evidence of the nerves being tubular. No phenomena indicate that any matter efcapes from them when they are divided. Befides, what veffels could have parietes fufficiently compact to retain fo fubtile a fluid as that of the nerves muft be. It is far more probable that it is retained in the nerves, in the fame manner as the electric matter is in electric bodies, by communication and infulation; and that the nervous fyftem is its only conductor, while all the other parts of the animal body are, with refpect to it, cohibent fubftances *.

* *Cuvier's Lectures*, vol. ii.

The theory of *fenforial power*, brought forward by Dr Darwin, has already been noticed.

Chap. III. *Of Irritability.*

111 General phenomena of irritability.

1. When any part of a living animal body that contains mufcular fibres, as a part of its compofition, is touched with a fharp inftrument, with a hot iron, or with a corrofive liquor; or when a fhock of electricity or galvanifm is made to pafs through it, a contraction takes place in the part, and this contraction is difcontinued when the ftimulus is removed, but is renewed on repeating the application.

2. The fame contractions take place in certain parts of a living animal body, from an exertion of the will.

3. Many parts in which the prefence of mufcular fibres has not been afcertained, poffefs the fame capacity of being excited to motion by ftimuli. Such are the ureters, the biliary ducts, the fmall blood-veffels, and probably the lymphatics; all of which, though not evidently mufcular, have a fibrous ftructure.

4. Some parts of the living animal body which appear rather nervous than mufcular, poffefs a contractile power, as the retina.

5. When the nerves which form a communication between a contractile part and the brain, in the higher orders of animals, are divided or compreffed, thofe parts which before contracted in obedience to the will, lofe this power; but,

6. Thefe parts, as well as every mufcular part, ftill contract on the application of ftimuli, particularly electricity and galvanifm.

7. Such parts of an animal body as have mufcular fibres, are thrown into contraction on the application of ftimuli, for fome time after having been feparated from the living body, provided that nervous filaments remain connected with the mufcular fibres.

8. It has been found, that the fibrine of the blood is

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susceptible of contraction on the application of the galvanic stimulus, after having been separated from the living body.

9. In some animals in which a nervous system has not been detected, as polypes, this contractile power seems to pervade every part of the animal.

10. Plants, in a greater or less degree, possess the power of moving on the application of stimuli; and in some species this motion is very remarkable. See N° 57.

The above are some of the principal phenomena which take place in organized beings with respect to irritability. They are so analogous, that we may attribute them to the same cause or the same vital power. This susceptibilty of being thrown into contraction on the application of stimuli is called irritability; and it is possessed in a greater or less degree by every organized being with which we are acquainted.

112 Definition of irritability.

We have restricted the term *irritability* to denote the susceptibility of the fibrous structure to contraction on the application of stimuli; but it is proper to remark that this term has not always been used in the same sense.

113 Different applications of this term.

Irritability has long been employed in medicine, as in common language, in reference to the passions, especially that of anger; and this appears to have been the original meaning of the term.

Multa fero ut placem genus irritabile vatum. HOR.

It is perhaps still more common to apply it to a morbid sensibility of the system; and we speak of a person being of a very irritable habit, or possessing a great degree of irritability, when we mean to say that he possesses a more than ordinary share of sensibility, liable to a more keen sensation of the same impressions.

"Or are your nerves too irritably strung."
ARMSTRONG.

Even the accurate Dr Whytt, to whom the proper distinction between irritability and sensibility must have been familiar, and by whom it is in general strictly regarded, sometimes falls into this inaccuracy. He speaks, in his work on nervous diseases, of "a delicate or easily irritable nervous system." In fact, this confusion of irritability with sensibility, appears to be a stumbling block to most physiological writers. We shall presently inquire how far they are independent of each other.

The term irritability, in its most received acceptation, as a property of the muscular fibre, seems to have been first employed by Glisson, about the middle of the 17th century. He distinguishes two kinds of irritability, primary or direct, and secondary or sympathetic *. Haller was, however, the first, who treated of irritability with any degree of accuracy. He confines it to the muscular fibre; though at the same time he will not allow it to many parts, the muscularity of which has never been questioned, and which, since his time, have, by decisive experiments, been proved to possess a considerable degree of contractile power. He completely distinguishes irritability from sensibility, with which he will have it to be totally unconnected; and he attempts to make a distinction between the irritability of the living, and that of the dead fibre †.

* *Glisson de Ventriculo et Intestinis.*

† *Haller's First Lines of Physiology*, chap. ii.

Dr Whytt, whose controversy with Haller respecting the nature of irritability and sensiblity is famous in the annals of medical warfare, admits three kinds of irritability: 1. That power of alternate contraction and dilatation which is peculiar to those organs we call muscles; 2. That uniform contraction which takes place in the dartos (one of the coats of the scrotum) and the pores of the skin; and, 3. That redness and inflammation which is excited in every sensible part of the body, as often as acrid things are applied to it; although this last is allowed by him to be only an effect of the first kind of irritability taking place in the small vessels of the part ‡. Thus, he reduces the three kinds to two, and we may perhaps consider his second kind only as a modification of the first.

‡ *Whytt's Physiological Essays*, Essay ii. part 2.

Among those who seem to have a sufficiently just idea of the nature of irritability, the word itself is not unfrequently misapplied. Thus, Vicq d'Azyr ‖, and Dumas §, in enumerating the functions of the animal body, called those of motion and sensation, irritability and sensibility. These latter are powers or capacities of living beings, and as such should be distinguished from the functions that depend on them.

‖ *Encyclop. Method. Anatom. Comparée.*

§ *Principes de Physiologie*, tom. i.

In considering the phenomena of irritability, it is necessary to take notice of the several kinds of stimuli which excite it. These have been reduced by Cuvier to five orders, viz. *volition; external actions* operating on *nerves; external actions* operating on the *fibre* itself; *mixed actions* operating on both the *nerves* and *fibres*, and certain *diseases* or *violent emotions*.

114 Stimuli exciting irritability.

When the animal body is in a state of health, and awake, the will exercises a prompt and constant influence over the greater part of the muscles, which, on that account, are denominated *voluntary* muscles. A small number of muscles, viz. those which produce the internal movements necessary to life, and which cannot be interrupted, such as the heart and the alimentary canal, are not subject to the will. It must be observed, however, that some of the muscles, that in man and most other animals are involuntary, are subject to the will in others. This is the case with the stomach in ruminating animals, the movements of which may be exerted at pleasure in two different directions. In some muscles, as in those of respiration, there seems to be a mixed action with respect to the will, as this faculty can interrupt their motion for a time, though, in general, this is continued from habit, without the will, or even consciousness of the animal. Those muscles that are absolutely involuntary, are continually excited by an extraneous irritating cause; for the blood which is brought to the heart on every dilatation, determines that organ to contraction, and the alimentary canal is affected in the same manner by its contents. It seems, therefore, that the will is not essential to the action of these muscles, and that it cannot interrupt their motion (c). A

115 Volition.

(c) There are facts which shew that the will has often considerable influence even on muscles that are universally styled involuntary. The abbé Fontana, when making experiments with *wheel polypes*, was led to believe that the heart, in these animalcules, is a *voluntary* muscle, and from this belief he learned, in some degree, to accelerate

Of Irritability. A muscle laid bare, and exposed to an irritating cause, will contract itself, even in the living subject, without being influenced by the will. It should seem, therefore, that though the muscles which we call voluntary, are usually put in motion by the will, they may yet be excited to action in opposition to that faculty.

116 Nervous energy. The will itself seems to act only through the medium of the nerves; and it is found that those nerves which supply the voluntary muscles, are generally the largest.

117 External stimuli. The external stimuli that act on the muscular fibre through the medium of the nerves, and on the fibre itself, are chiefly of a mechanical and chemical nature, as concussions, punctures, lacerations, all of which are capable of producing convulsive motions in all the muscular parts to which the nerves extend.

118 Galvanism. One of the most remarkable of these stimuli is the galvanic influence. It is well known that the experiments by which this influence is made to act on the muscular fibre, consist in establishing between a muscle and the trunk of the nerves which extend to it, an external communication with one, or a series of substances placed close to each other. Metals are not the only means that may be employed in this operation; and in general, the conductors are not the same as those of electricity. Experiments have sometimes been successfully performed, when an interval was left in the series of excitators: this circumstance, in the opinion of Cuvier, proves the existence of an atmosphere.

The moment the contact takes place, the muscle suffers violent convulsions. These experiments succeed on the living body, or animals recently dead, and even on parts separated from the body, precisely in the manner of those which Haller accounts for on the principle of irritability. Neither pointed instruments nor acrid liquors are necessary; and the galvanic experiments even succeed when these means have failed.

119 Distension. Distension has been observed to have a powerful effect in exciting irritability.

120 Violent passions. Violent passions may, to a certain degree, be considered as the acts of the will strongly excited. These, in some cases, have an influence even on the involuntary muscles; for it is no unusual thing for palpitation of the heart, and sometimes even a suspension of its motion, to be the consequence of strong passions. These actions, however, are to be prevented by moderating the excess of sensibility by which they are occasioned. Even in nervous diseases, which appear to be the least connected with those passions whose influence is more immediately felt, the will is often capable of preventing or retarding the approach of nervous symptoms, when the patient is determined to resist the paroxysm.

From what has been said, it appears that, in the superior classes of animals, all the orders of stimuli, either act through the medium of the nerves, or that they are capable of being modified or controuled by the will, the exertion of which depends on nervous influence.

121 Cause of irritability. With respect to the immediate cause of irritability, there have been several opinions. One of those which has been most generally received is, that irritability is intimately connected with sensibility; or, that it is an immediate effect of the nervous power. This was the opinion of Whytt and Cullen, the former of whom endeavours to prove it by the following arguments.

122 Whytt's arguments in support of nervous influence.

1. We almost always observe the irritability of the muscular organs of the human body to bear a proportion to their sensibility. Thus, children, and people of delicate nerves and very quick feelings, are most subject to convulsive and spasmodic diseases, while on the other hand old people, and those of less delicate sensibility, have a muscular system that is not so irritable.

2. Whatever increases the sensibility of the muscles, also increases their irritability.

3. Whatever lessens or destroys the sensibility of the muscles, also lessens or destroys their irritability or power of motion.

4. That the motions of irritated muscles are owing to the sensation excited by the stimulus applied to them, Dr Whytt thinks highly probable, if it be considered that we are in fact conscious of many involuntary motions in our own bodies, proceeding from a particular sensation, either in the organs moved, or in the neighbouring parts. *

Dr Cullen was so fully convinced of the necessity of nervous influence to produce muscular contraction, that he considered the muscular fibre to be only a continuation of the nervous fibre. See MEDICINE, N° 73.

* *Physiological Essays*, Essay ii.

123 Haller's opinion of the *vis insita*. Haller, as we have said, strenuously maintained, that irritability was quite independent of the nerves, and was an inherent power or *vis insita* of the muscular fibre. Indeed there are several circumstances which would induce us to believe that irritability is at least, in some cases, independent of nervous influence. We have seen (N° 111.) that it takes place in those animals in which there is no appearance of nerves; and that it is very remarkable in some species of vegetables, in which none but the most fanciful physiologists have dreamed of finding a nervous system. Nay, it appears that the fibrine of the blood, which we can scarcely suppose to be affected by the nervous power, when taken out of the body, is still susceptible of imitation.

124 General conclusion on this subject. From a comparison of all these circumstances, we must either conclude, that the irritability of living muscles, and of the superior animals, is different from that of the fibrine, of polypes and plants; or, if we admit that nervous influence is essential to irritability, we must also allow that this influence descends to the latter class of organized bodies.

125 Chemical doctrines of irritability. Before we quit the subject of irritability, we must notice the chemical hypotheses that have been lately proposed, to explain the immediate cause of this faculty.

126 Girtanner's opinions. The first of these is that of Girtanner, who considered oxygen as the principle of irritability. The arguments

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celerate and retard the motion of his own heart. We have even heard of a person who had such a command over both heart and lungs, that he could, at pleasure, arrest the motion of both, and assume all the appearance of a lifeless corpse. Many of those muscles, which, in ordinary subjects, are not obedient to the will, as those of the *nose* and *external* ear, may, however, become so by habit or patient assiduity in cultivating their action.

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arguments on which he founded this opinion are the following.

1. The irritability of organized bodies is always in a direct ratio to the quantity of oxygen they contain.

2. Every thing that augments the quantity of oxygen in organized bodies augments at the same time their irritability.

3. Every thing that diminishes the quantity of oxygen diminishes likewise their irritability.

He distinguishes the organized fibre by three different states:

1. A state of health, or the *tone* of the fibre, in which the oxygen exists in its proper quantity.

2. A state of *accumulation*, in which the fibre is overcharged with the oxygen or irritable principle.

3. A state of *exhaustion*, in which the fibre is more or less deprived of it.

He likewise arranges the substances, that are capable of coming into contact with the irritable fibre, into three classes.

The first comprehends those substances that have the same degree of affinity for the irritable principle or oxygen, as the organized fibre itself; hence the substances produce no effect upon it.

The second comprehends those substances that have a less degree of affinity for oxygen than the organized fibre has: hence these, when they come into contact with it, surcharge it with oxygen, and produce a state of *accumulation*. They are called negative stimuli.

The third comprehends substances for which oxygen has a greater affinity than it has for the organized fibre. These, therefore, deprive the fibre of its oxygen, and produce a state of exhaustion. They are called positive stimuli.

By way of answer to this fanciful doctrine, we may observe, that if oxygen were so essential to irritability as is supposed in Girtanner's positions, those animals which respire most oxygen should possess most irritability, and those which are capable of living for a long time in deoxygenated air, should have their irritability very low. Now, the reverse of this is found to take place. The muscular fibres . birds which respire more oxygen than most other animals, possess but little irritability, while reptiles and worms, which can live for a long time without oxygen, are universally and strongly irritable *.

* *Johnson's Animal Chemistry*, vol. iii.

127 Hypothesis of Humboldt.

The other opinion is that of Humboldt, who considers the galvanic fluid as the source of nervous power, and the primary cause of irritability. He lays down three principles as necessary to excite irritability; viz. 1. Oxygen, which forms combinations with different acidifiable bases. 2. The acidifiable bases (carbone, hydrogen, azote, and phosphorus,) of the fibre, with which the oxygen may combine. And 3. The galvanic fluid.

The galvanic fluid produces, according to Humboldt, the same effect in the animal economy, as the electric fluid in the mixture of azote and oxygen. It is this galvanic fluid that, being conveyed by the nerves, brings about the combinations of the oxygen with the different acidifiable bases of the fibres; but when the nerve of a part is tied, it prevents the fluid from passing, which explains the reason of the irritability being destroyed.

The oxygen necessary for these unions is carried by the arterial blood in the course of circulation; and the acidifiable bases, which are to unite with it, are found to be already present in the fibre.

4

He found that every thing that augments too much the quantity of the acidifiable bases diminishes the irritability; and that every thing that increases too much the quantity of oxygen, likewise diminishes it; and he thinks it very probable, that the same takes place with respect to the proportion of the galvanic fluid.

It is therefore only in a just equilibrium of these principles that the necessary irritability of the parts consists.

Upon these principles this philosopher thus explains the production of muscular motion. "In a state of repose, the nerve being inserted in the muscles, the galvanic fluid is put into equilibrium in organs that touch each other. The spontaneous motion is made by a surcharge of galvanic fluid into the nerve. It appears that the instant we wish to make a motion, the galvanic fluid produced in the brain, is carried *en masse* towards the part that ought to move, and surcharges the nervous fibres. A discharge from the nerve is then made into the muscles. The particles of these last, animated by increased affinities, approach each other, and it is this that constitutes the phenomena of muscular motion *."

* *Johnson's Animal Chemistry*, vol. iii. p. 24.

128 Laws of irritability by Dumas.

Dumas lays down the following fundamental laws respecting animal irritability.

1. The essential characteristic of irritability consists in a series of contractions and dilatations, determined either by the impression of an external stimulus, or by the simple exertion of the will.

2. Irritability is independent of the action of the nerves; and though generally diffused throughout the animal organization, it belongs rather to the muscular fibre than to any other structure. Its action is in proportion to the number of fibres upon which the irritating causes can exert their influence.

3. Irritability is a relative faculty which is not indiscriminately obedient to every species of excitation, but only to those which have some relation to it in the different parts of the living body.

4. There belongs to each organ a specific irritability which requires a peculiar stimulus, accommodated to its nature, and to the kind of functions which it exercises.

5. Irritability has certain vicissitudes of diminution and increase, which vary in the different species of animals, in the different organs of the same animals, and under the different circumstances that successively occur in the life of an individual.

6. Irritability is developed with most energy at the moment of death, and immediately after this has taken place.

7. It is multiplied and revived in proportion as the organ which has lost it is divided into a greater number of pieces.

8. It diffuses itself in each part with a velocity proportioned to the activity, number, and duration, of the irritations by which it is excited.

9. There exist mutual relations with respect to influence between sensibility and irritability, though each of them is essentially distinct from the other.

10. The exercise of this faculty supposes in the organs a moderate degree of cohesion, above or below which the action of this force is enfeebled, obstructed, or opposed *."

* *Principes de Physiologie*, tom. iii. p. 53.

CHAP.

Chap. IV. *Of Animal Motion.*

129 Organs of motion. The organs of motion vary confiderably in their nature and connection in the different claffes of animals. In fome tribes, as in the animalcules and polypes, no diftinct organs can be obferved. In all above thefe, however, there are evident mufcular fibres, and in many there are hard parts or ftrong membranes, which ferve as points of attachment and fulcra of motion to thefe fibres. The mufcular fibres are to be confidered as the effential moving organs, while the parts to which they are attached are merely the paffive functions of this organ. It would be out of place here to enter on a comparative account of the organs of motion; and there is the lefs occafion for it, as they have been more or lefs fully defcribed in the former part of the work. The bones, ligaments, mufcles, and tendons, with their appendages, as they appear in man, have been amply defcribed in the firft and fecond chapters of the Firft Part of Anatomy; and thofe of other animals have been briefly noticed in the Second Part of that article. Such of our readers as wifh for a more particular account, may confult Cuvier's Lectures vol. i. or Blumenbach's Comparative Anatomy, chap. 1, 2, 3, 4, 5, and 22.

130 Principles of mufcular action. Many of the phenomena of mufcular motion, as they take place in man, have alfo been related under Anatomy, N° 85 and 86. We fhall here therefore only enumerate and briefly illuftrate thefe phenomena, and fhall then proceed to confider a moft interefting part of the phyfiology of motion, the progreffion of different animals.

Dr Barclay, in his late excellent work on the mufcular motions of the human body, has confidered the general fubject of mufcular action under the following heads, which may be confidered as fundamental principles.

1. Flefhy fibres that are continued into tendon by a ftraight line, fhorten the mufcle which they compofe, in the fame degree in which they fhorten themfelves; thofe fibres which enter the tendon obliquely, fhorten it more, and ftill more in proportion to their degree of contraction, as they deviate more from the line of the tendon, and approach nearer to the perpendicular, in which laft direction they would fhorten the mufcle moft with the leaft contraction.

This may be illuftrated in the following manner. Let AB (fig. 1.) reprefent a tendon, and CD a flefhy fibre; and let us fuppofe that AB is the diameter, and CD the radius of the fame circle ADB. It is evident that if the fibre CD fhould contract fo as to bring the point C of the tendon to the point G in the ftraight line, the extremities of the tendon A, B, (which are fuppofed to be moveable) would come refpectively to E and F; and the fituation of the tendon itfelf would be reprefented by the angle EGF. If the fibre could be fuppofed to contract fo as to bring the point C to D, the two parts of the tendon CA and CB, would come in contact. If, on the other hand the fibre CH, which enters the tendon obliquely, were to contract to H, fo as to bring the point C to H, the point A would be drawn but a little beyond the middle point C, fo that although this latter fibre is contracted to as great an extent as the former, it has not brought the extremities of the tendon fo near together.

Plate CCCCXVII. Fig. 1.

2. When two fibres enter a tendon on oppofite fides and contract at the fame time, they will draw the tendon in the diagonal, and the more nearly the angles which they form with the tendon approach to right angles, the more will the length of the mufcle be fhortened in proportion to the degree of contraction of the fibres.

Let the fibres BC, BD, BE, BF, BG, (fig. 2.) be flefhy fibres, inferted into the tendon AB, at the point B, and let us fuppofe that all thefe fibres co-operate in bringing the point B to the point G, in the ftraight line BG. Now the ftraight fibre BG will be fo much fhortened when B comes to G, as to be obliterated, while the oblique fibres EB and FB will be fhortened only to E *a* and F *b*, and the more oblique fibres CB and DB will remain of the length of C *c* and D *d*. Fig. 2.

3. All mufcles that are inferted into bones, are thereby furnifhed with levers, and as in the action of all levers there are alfo a fulcrum, a power, and a refiftance, thefe in different cafes will be differently fituated with refpect to one another.

a. In the motions of the head backward and forward on the atlas, the fulcrum is fituated between the power and the refiftance; or the lever is of what is called in mechanics, the firft kind. See Mechanics, N° 33.

b. When the tibia refts upon the aftragalus, and the heel is raifed by the mufcles of the calf of the leg acting on the tendo achillis, the refiftance (which in this cafe is the preffure of the tibia) is fituated between the power and the fulcrum, which are here refpectively at the heel and at the toes; or the lever is of the fecond kind.

c. In raifing a weight at the palm of the hand, and bending the arm at the joint of the elbow, the power of action in this joint is fituated between the refiftance and the fulcrum, which are here refpectively at the palm of the hand and the *diftal* extremity of the humerus (D), or the lever is of the third kind.

The fhortnefs of the lever, and the confequently great force of the mufcular power required to overcome the refiftance in this laft cafe, may be thus illuftrated. Let AB (fig. 3.) reprefent the *radius* articulated at B with the *humerus* BC; let DFE reprefent the *biceps flexor* mufcle running along the *humerus*, and attached to the *radius* at E; and fuppofe a weight W hung to the diftal extremity A of the *radius*. Now, BH will reprefent the lever of refiftance, and BG perpendicular to it the lever of the mufcle, which is in this cafe extremely fhort. Fig. 3.

4. As, other things being equal, all mufcles produce a greater extent of motion by a lefs proportional degree of contraction, and confequently a lefs proportional change in their fibres, than if they were fhorter; thofe mufcles which follow a direct courfe are feldom attached at the neareft points of the two bones with which

(D) In Dr Barclay's nomenclature, that extremity of a bone which is towards the trunk is called *proximal*, and that extremity which looks from the trunk is called *diftal*.

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which they are connected. Hence, beside the advantages already mentioned, relations are thus formed between parts at a distance, and the mutual dependence of the functions and their organs is extended and strengthened. On the contrary, those muscles that are not extended along the surface of the bones to which they are attached, are observed to follow an oblique direction, by which they acquire not only contractibility and length, but at the same time a shorter lever than if they had been inserted at the same place with a less obliquity.

5. Of muscles attached to ribs that are parallel, equally moveable, and at right angles to the vertebral column, those that follow a direct course from one to the other, will act on each by equal levers, and make them approach with the same velocity; while those that observe an oblique course will act on each by different levers, and make them approach with different velocities.

Fig. 4. Let AB and CD (fig. 4.) represent two parallel ribs, articulated with the vertebral column at A and C, where they are equally moveable; and let DB and DE be two muscles, the former observing a direct, and the latter an oblique course. The levers of DB will be AB and CD, which, as AC is parallel to BD, are evidently equal; but the levers of DE will be CF and AG, which being of different lengths, the muscle must act with different degrees of force on the different ribs, so that it will make CD, on which it acts with the longest lever, approach AB, faster than it will make this latter approach the former.

Corollary.—When bones are not parallel, the muscles that cross in the interval between them, must fall obliquely on both, as it is impossible for a straight line to be at the same time perpendicular to two other lines, unless these be parallel.

6. As all bones move on a centre or axis of motion, while the muscular attachments move in a circumference, the muscles, in changing the relative position of any two bones, must at the same time, be changing the direction of their own action, and varying their lever.

Fig. 5. Let AB and CD (fig. 5.) represent parts of two parallel ribs, and let AB be moveable on the centre A, and let CF and GE be two muscles inserted obliquely into AB at F and E. Now suppose that by the action of these muscles, AB is brought into the position A*b*. The points of attachment of the two muscles to AB, will now be *f* and *e*, and the muscles will be C*f* and G*e*, having changed their length, situation, obliquity, and lever.

7. All muscles where the points of attachment move in a circle, draw either towards the centre, or towards the circumference.

8. If any two bones could, by the action of their muscles, be made to approach in a parallel direction, the oblique muscles attached to their parallel and approaching surfaces, would perform a greater extent of motion with a less shortening of their fibres, than any straight muscles attached to the same parallel surfaces.

Fig. 6, & 7. Let AB and CD (fig. 6. and 7.) be parts of two ribs that are parallel, and that will continue parallel till they are brought in contact by the action of the straight muscles AC, EF, and BD, or by the action of the oblique muscles CE and DE (fig. 7.) and FA and FB (fig. 6.). It is evident, that when the point E comes in contact with F, the length of the straight muscles must be obliterated, while that of the oblique muscles will only be shortened by *c* E and *d* E in fig. 7. and *f* A and *g* B in fig. 6.

9. As, however, no two bones can approach one another in a parallel direction, at least by the action of a single muscle, and as no muscle can continue to act in a direction perpendicular to their two approximating surfaces; a muscle entering them at right angles, when they are parallel, may be placed so near to the centre of motion as to carry the bones through a given space, with a less shortening of fibres than any oblique muscle that has the same origin, but is inserted at a distance, and acts through the medium of a longer lever. Further, a muscle with a less obliquity may be so situated as to carry the bones through a given space, with a less shortening of fibres than any other muscle of the same origin, but of a much greater obliquity.

Fig. 8. Let AB and CD (fig. 8.) be two ribs, of which AB is moveable about the centre A; and suppose that by the shortening of the straight muscle EF, and of the two oblique muscles, EG and EH, AB is brought into the position A*b*. The points of attachment, after moving in the segments F*f*, G*g*, and H*h*, will now be respectively at *f*, *g*, and *h*. Now, on the centre E, with the radii E*f*, E*g*, and E*h*, describe three different circular segments. The difference between the present and former lengths of the most oblique muscle EH, will be *e*H, while the differences between the present and former lengths of the muscles EG and EF, will be only *ε*G and *η*F respectively.

10. The shortenings which any muscle suffers in carrying round the point of its attachment through a given space, will partly depend on the length of its lever, partly upon its degree of obliquity, partly on its drawing *peripherad* or *centrad*, and partly on its acting without or with a pulley (E).

11. The lever of a muscle, which is varied with every degree of obliquity, is also varied by every change in the centre of motion. Where bones are connected by large surfaces, the centre of motion frequently shifts from one part to another; but in general it approaches towards that aspect whither the bone is moving at the time; and as it advances, the muscles recede, to increase their force.

a. The lever of resistance, as well as of the power, is varied by the several changes of position; is sometimes shortened at the time that the lever of the power is lengthened; and *vice versa*.

If

(E) The terms *peripheral* and *central*, are employed by Dr Barclay, to denote the aspects of any organ, according as they respect the *circumference* or the *centre* of the organ; and when the termination of these words is changed from *l* into *d*, they denote, like the other terms of his nomenclature, the direction in which the action of these parts is exerted. See Barclay's Anatomical Nomenclature.

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If AB (fig. 9.) represent the radius, BC the humerus, DE the biceps flexor muscle, and R the resistance hung to the distal extremity of the radius, it will be evident that, when BA is, by the action of the flexor muscle, brought into the position B*a*, the lever of resistance will no longer be BA, but BH, equal to a perpendicular straight line drawn from B, the centre of motion, to the plane of resistance; and, as the lever of resistance has been shortened, the lever of the muscle has been proportionably lengthened. Were the radius to resume its former position, the reverse of these circumstances would take place.

b. Sometimes again, the lever of the power and of the resistance are lengthened or shortened at the same time.

Let AB (fig. 10.) represent the tibia, BC the femur, and DEF the crureus muscle; and that the femur, with the weight of the body, is to be raised to the situation B*c*; the centre of motion will, during extension, approach towards the muscle at the rotular aspect, while the plane of resistance, as is evident from the figure, will be approaching to the centre of motion.

c. In the changes of attitude, while a bone is turning on its centre of motion, the centre itself is often at the same time describing, either the segment of a circle, or a line composed of circular segments.

Let AB (fig. 11.) represent the foot, BC the *tibia*, CD the thigh bone, and DE the trunk; and let us suppose that it is required to bring the three last, by the action of their muscles, to the perpendicular BF, so that BC shall occupy the situation of BG, CD the situation of GI, and DE the situation of IF; the point C on the centre B will move in the segment CG, and as C is changing its position in CG, the point D, which moves round the point C as its centre, will, if the extensions be regularly performed in the same time, describe such a curve as DI; for as the point D must necessary move atlantad and sternad, (F) in order to preserve the centre of gravity, the general direction of its course must be known; and if CG be divided into equal parts, and at each of the divisions a circle described with the radius CD, the points in DI, corresponding in number with the points in CG, and at equal distances in the sternal direction, will each be found in the circumference of one of the circles described successively round the point C as it passes along the segment CG.

In like manner, if the extensions of CD and DE be regularly performed in the same time, the point E will describe such a curve as EF, the points in EF being in the circumferences of the several circles successively described round the point D as it moves along the curve DI.

12. When we examine the structure of the animal system, we shall generally find that the motions of the bones, as produced by the muscles, are the combined effects of different forces, and hence that a small number of muscles is enabled to produce, with steadiness and accuracy, an almost infinite variety of changes *.

* *Barclay on Muscular Motion*, Part ii. chap. 3.

For more on the general subject of muscular action, and for an account of the principal motions of the human body, we must refer to Dr Barclay's publication.

One of the most interesting enquiries respecting animal motion, is that of the progression of different animals, or of the powers of loco-motion.

131 Progressive motions.

Those animals which possess the faculty of changing their place, exercise this faculty by very different organs. Some can only creep, as worms, and many mollusca; others can only swim, as all fishes, many of the mollusca, and some of the testacea. Most birds can both fly, walk, and run, while a few do not possess the power of exercising the first of these motions. All the mammalia, and most reptiles, properly so called, can walk, run, climb, leap, and perform a variety of other motions; and a few of the former class can imitate the flying of birds. We shall briefly examine the mechanism of these different actions, but by way of introduction, we shall first consider how the action of standing is performed.

132 Standing.

Standing, in most animals, is solely the effect of the continued action of the extensor muscles of all the joints, as is evident from the circumstance, that if an animal, while standing, suddenly dies, or in consequence of some powerful cause, as a strong electric shock, ceases to make the necessary efforts for preserving the upright position, all the articulations of the legs yield to the weight of the body, and bend under it. In some animals, however, the extension of the muscles is so much assisted by powerful ligaments attached to the articulations of the legs, that they are enabled to continue standing for a much longer time, and with much less fatigue than most others. This is the case with birds that perch, and it is particularly remarkable in the stork, which by means of this peculiar mechanism is able to stand on one foot for several days together.

The action of standing is somewhat different, according as the animal stands on two feet or on four.

133 Standing on two feet.

That a body may be supported in a vertical position, it is necessary that it be so disposed as to be in a state of equilibrium, or that it be so balanced that a perpendicular line from the centre of gravity shall fall within its base. See MECHANICS, N° 193, et seq. It is evident that the more extensive the base is on which the body stands, the less is the danger of its losing its balance. Man can very easily preserve himself in the vertical position, from the broad basis formed by his feet, and from the great power he possesses of separating these to a considerable distance. This latter depends chiefly on the greater weight of his pelvis, and the length and obliquity of the neck of the thigh bone, by which this bone is carried more outward, and removed farther in its articulation, than in any other animal. In man, too, the foot is peculiarly adapted to stand firmly on the ground, from the flatness of its inferior surface, and from having the heel bone so formed as to come in perfect contact with the ground. The muscles that move the foot are also very advantageously inserted, and the extensor muscles of the heel are proportionably thicker than in most of the mammalia.

The thigh of man, when in the erect posture, is in a straight line with the trunk and the leg, whereas in quadrupeds, it is situated close upon the flank, and forms an acute angle with the spine. On this account, the thigh bone of quadrupeds is flat, and proportionally weaker than that of man. The extensor muscles of the thigh are proportionally stronger in man than in the other animals; and as the thigh bone moves upon the pelvis in every direction, these extensors are in man so considerable, that he is the only animal that possesses what are properly called hips.

In consequence of this structure, the human sacral extremities are furnished with a sufficient base, and form very

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very solid bodies for supporting the trunk. Man also possesses several advantages for maintaining the general equilibrium of the body, especially the facility with which he holds his head in the erect posture, owing to the position of the occipital bone, and the horizontal direction of the eyes and mouth. See the article MAN, N° 5 and 6.

The quadrupeds that sometimes try to stand on their hind feet only, in order that they may either employ their fore feet in taking hold of some object, or avoid keeping their head too low, seem rather to sit than to stand. Their trunk rests at the same time on their hind feet, as far as the heel, and on the buttocks; it is still necessary, however, that their head and neck should be proportionally small, as in *monkeys*, *squirrels*, *opossums*, *&c.* otherwise the weight of those parts would be too great for the force employed in their elevation; but even when seated, the animal is generally obliged to rest on the fore feet, as may be observed in *dogs*, *cats*, *&c.*

Some quadrupeds use their tail as a third foot, to enlarge the base of the body: and when it is strong, it is capable of contributing to their support for some time. We find examples of this in the *kangaroos* and *jerboas*.

We have already noticed the mechanism in the feet of birds, which enables these animals to support themselves on two legs, though they do not stand in a vertical position, and though the atlantal part of their bodies is advanced more beyond the centre of gravity than the sacral part. Other advantages possessed by birds in this respect are, the great flection of the thigh bone and tarsus; the length of the anterior toes, and the length and flexibility of the neck.

134 Standing on four feet.

An animal which stands on four feet is supported on a very considerable base; but from the great weight of the head and neck in these animals, their centre of gravity is nearer to the atlantal than to the sacral extremities (F). It is evident from this, that in quadrupeds, the former must sustain almost the whole weight of the body; and we find, accordingly, that they are furnished with very strong muscles. In short, all that the sacral extremities seem to want in muscular force, appears to be transferred to the atlantal.

As in most quadrupeds the head inclines towards the horizon, and the neck is often very long, very powerful means are required to sustain the former. These means are furnished by the great size and extensive attachments of the muscles of the neck, and especially in many quadrupeds by the cervical ligament. In the *mole*, which employs its head to raise considerable burdens of earth, the cervical muscles are peculiarly strong, and the ligament is converted into bone.

The body of a quadruped hangs between the four legs, and by its weight tends to draw the spine downwards. This is counteracted by the abdominal muscles, especially by the straight muscles, which produce a curvature in the opposite direction. The abdominal muscles act with peculiar force in arching the spine upwards in those mammalia that are covered with scales or spines, and are accustomed to roll themselves upon the approach of danger, as the *hedgehog*, the *armadillos*, and the *pangolins*.

Oviparous quadrupeds or reptiles, have their thighs directed outward, and the inflections of the limbs take place in planes that are perpendicular to the spine. In these, therefore, the weight of the body must act with a much longer lever, in opposing the extension of the knee-joints; and accordingly they have the knees always bent, and the belly dragging on the ground between their legs, whence their name of *reptiles*.

In walking on a fixed surface, the centre of gravity is alternately moved by one part of the extremities, and sustained by the other, the body never being at any time completely suspended over the ground. 135 Walking.

Animals which can stand erect on two legs, such as man and birds, walk also on two legs. But several quadrupeds that cannot stand on two feet but with great difficulty, may yet move in that posture for some time with sufficient ease. This arises from its being in general less painful to walk than to stand, the same muscles not being continued so long in action. And also it is less difficult to correct the unsteady motions by contrary and alternate vacillations (a thing easy in walking), than it is to prevent them altogether. 136 Walking on two feet.

When man intends to walk on even ground, he first advances one foot; his body then rests equally on both legs, the advanced leg making an obtuse angle with the tarsus, and the other an acute one. The ground not yielding to the point of the foot, the heel and the rest of the leg must of necessity be raised, otherwise the heel could not be extended. The pelvis and trunk are consequently thrown upward, forward, and somewhat in a lateral direction. In this manner they move round the fixed foot as a centre, with a radius consisting of a leg belonging to that foot, which, during this operation, continually diminishes the angle formed with the tarsus. The leg which communicated this impulse is then thrown forward, and rests its foot upon the ground; while the other which now forms an acute angle with its foot, has the heel extended in its turn, and in like manner makes the pelvis and trunk turn round upon the former leg.

As each leg supports the body in its turn, as in standing on one foot, the extensor muscles of the thigh and knee are brought into action, to prevent these articulations from yielding; and the flexors act immediately after, when the leg having thrown the weight of the body on its fellow must be raised before it can again be carried forward. As the undulatory motion that necessarily attends a man's walking, cannot be perfectly regulated on both sides, he cannot walk in a perfect straight line, nor can he walk in a direct course with his eyes shut.

In walking down an inclined plane, or descending a staircase, as the advanced leg is placed lower that that which remains behind, the extensors of the leg must act more powerfully to prevent the body from falling backwards. Again, on ascending such situations it is requisite at each step, not only to transport the body horizontally,

(F) These terms signify the same as *superior* and *inferior* in man, *anterior* and *posterior* in quadrupeds; but are more convenient, as applying indiscriminately to both. *Atlantal* denotes what is next the *atlas*; *sacral* what is next the *sacrum*. See *Barclay's Nomenclature.*

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zontally, as on walking on level ground, but to bear it up againſt its own weight, by means of the extenſors of the knee of the advanced leg, and thoſe of the heel of that which is behind; this is the reaſon of the knee and calf of the leg being fatigued in aſcending; and the fatigue is relieved by inclining the body forward, becauſe then the lever by which its weight acts on the knee is ſhortened.

Running is only a ſucceſſion of ſhort leaps, and it will be underſtood from what we ſhall preſently ſay of leaping.

137 Walking on four feet.

When a quadruped walks, he firſt ſlightly bends the articulations of the hind legs, and then extends them, in order to carry forward the body, which motion is conſiderably aided by the extenſors of the knee and the heel. The breaſt being thus thrown forward, the fore legs incline backward, and the animal would fall, did it not inſtantly throw them forward in order to ſupport itſelf. It then draws up the trunk upon the fore legs, and renews its former efforts.

In this walking, each ſtep is performed by two legs, one belonging to the fore, and the other to the hind pair. Sometimes theſe are of the ſame ſide, and ſometimes thoſe of oppoſite ſides. The motion of a horſe who ſteps forward in the latter way, is termed a pace.

In the animals that have the fore feet longer than the hind; and have their ſtrength chiefly in the anterior part of the body, the principal impulſe is given by extending the fore foot. The hind foot then riſes to follow it, and it is not until the moment that the latter extends itſelf in its turn, that the fore foot is raiſed. This is the manner in which the *giraffe* is ſaid to move.

But when the fore legs are conſiderably diſproportioned to the others, and particularly when the poſterior extremities are feebly and badly articulated, as in the ſloths, the animal is obliged to drag itſelf forward, by firſt extending the fore legs, and then bending them ſo as to draw the body after them. Hence the progreſſion of the ſloth is ſo laborious.

Thoſe animals which have their fore legs very ſhort in proportion to their hind legs, would be incapable of ſufficiently ſupporting their bodies, and muſt fail forward on each impulſe of the latter, had they not the precaution to make a prancing movement; that is, to raiſe the anterior extremities entirely off the ground, previouſly to their being impelled onward by means of the hind feet. Accordingly, ſuch animals cannot in propriety of language be ſaid to walk; they only move forward by leaps. This is the caſe with hares, rats, and particularly jerboas. Indeed, theſe animals cannot be ſaid to walk at all, except in the action of aſcending. When they attempt to walk ſlowly on level ground, they are obliged to move themſelves by the fore feet, and merely to drag after them the hind pair. This may be obſerved in rabbits, and ſtill more diſtinctly in frogs.

138 Leaping.

In leaping, the body riſes completely from the earth, and remains without any ſupport for a ſhort period, the duration of which depends on the force with which the leap has been made. This action is performed by a ſudden extenſion of all the muſcles belonging to the ſacral articulations, immediately after they have undergone an unuſual degree of flection. By this general extenſion theſe articulations receive a violent motion, the impulſe of which is communicated to the center of gravity of the body, and it is thus projected with a determined velocity, which is more or leſs in oppoſition to its weight. The projectile force and extent of the leap depend on the proportional length of the bones, and ſtrength of the muſcles. Thoſe animals, therefore, leap beſt that have the ſacral extremities longer and thicker than the atlantal; as the *kangaroos*, *jerboas*, *frogs*, *alticæ*, *grylli*, *fleas*, *&c.*

Small animals leap proportionally much farther than the larger ſpecies; and we know of none whoſe muſcular ſtrength, in this way, can be put in competition with that of a flea, which on a moderate computation is known to leap to a diſtance of at leaſt 200 times its own length. The direction of a leap depends on the ſituation of the centre of gravity with reſpect to the member by which the impulſe is given. Hence, only man and birds can leap vertically, becauſe they alone have the trunk ſituated above the members by which the leap is effected. Quadrupeds, and moſt inſects, can only leap forward; but ſpiders, which have ſeveral long feet on each ſide of their body, can alſo leap ſideways.

Running. 139

Running conſiſts of a ſeries of low leaps performed alternately by each leg. It differs from walking, in the body being projected forward at each ſtep, and in the hind foot being raiſed before the anterior touches the ground. It is more rapid than the quickeſt walk, becauſe the acquired velocity is preſerved, and increaſed at each bound by a new velocity. Running, therefore, cannot be inſtantaneouſly ſuſpended, though a ſtop may be put to walking at each ſtep.

In running, the animal inclines its body forward, that the centre of gravity may be in a proper poſition for receiving an impulſe in that direction from the hind leg; and it is obliged to move the fore leg rapidly forward, to guard againſt falling.

Man varies his manner of running, only by taking longer or ſhorter ſteps, or giving to this motion a greater or leſs degree of rapidity; but quadrupeds vary this motion by the different order in which they raiſe each foot, or bring it to the ground.

Trotting. 140

Trotting is a mode of running in which the feet diagonally oppoſite riſe at once, and fall at once, each pair alternately, but in ſuch a manner, that for a moment all the four feet are off the ground. This produces a regular motion, and the ſound of the animal's ſteps are heard two and two in ſucceſſion.

Galloping. 141

Galloping is a running motion in which the animal raiſes the anterior feet at each ſtep, and throws the body forward by the extenſion of the poſterior feet. When the two fore-feet deſcend at the ſame time, and are followed by the two hind feet alſo deſcending together, the motion is called a *full gallop*, which is the moſt rapid a *horſe* can perform, and the only mode of running in *dogs*, *hares*, &c. In this kind of gallop the ſteps of the horſe are likewiſe heard by two beats at a time. The *common gallop* is when the two fore-feet are lifted unequally, and fall one after another. This may be divided into *gallops* in which the horſes footſteps are heard by a ſeries of three or four beats, becauſe the poſterior feet may fall to the ground either both together, or one after the other.

There are ſeveral kinds of animals which leap by the means of organs different from feet, but always by a ſudden extenſion of ſeveral articulations.

Serpents leap by folding their bodies into ſeveral undulations;

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dulations, which they unbend all at once, according as they wish to give more or less velocity to their motion; some may be assisted by the scales of their belly, which they can elevate and depress, but only a few genera are capable of employing this means.

Some fishes also leap to the tops of cataracts by bending their bodies strongly, and afterwards unbending them with an elastic spring.

The long-tailed *cray-fishes*, particularly the *shrimps*, leap by extending the tail after it has been previously bent under the body.

The larva of the *fly*, vulgarly called the maggot, forms itself into a circle, contracts itself as much as possible, then suddenly unbending, darts forward to a considerable distance.

142 Climbing. The motion of climbing, so useful to many of the inferior animals, consists in hanging from, and strongly grasping any object susceptible of being seized by the fingers, toes, or tail, and thus rising, by successive efforts, in a direction opposite to the animal's weight. From this explanation it is evident that those animals which have the divisions of their extremities most distinct and flexible, will be the best climbers; and accordingly we find that the animals called *quadrumanous*, as the apes, lemurs, and a few others, perform this action in the most perfect manner. Man is but an indifferent climber, as he can only grasp with his hands. In *oppossums*, *ant-eaters*, and *sloths*, one of the toes is distinct, like the thumb in man, apes, and lemurs; or else they have a considerable protuberance on the heel, which has the same effect. Many animals, as some of the *monkeys*, some species of *opposum* and *ant-eater*, the *manis*, &c. have a very flexible prehensile tail, which assists them in climbing. The animals of the cat genus have very sharp talons, by which they are materially assisted in this kind of progression, as they enable them to adhere firmly to the bark of trees, &c. Creepers, nut-hatches, woodpeckers, and other climbing birds, support themselves in a similar manner.

143 Flying. The motion of flying, by which an animal can support itself for some considerable time in the air, can properly be said to be performed only by birds: for though bats can imitate this motion with tolerable success, and the galiopithecus, flying-squirrels, and flying-opposums, appear to fly from one tree to another, the motion of the former cannot be supported for so long a time as that of birds; and the motion of the latter animals can be considered only as a leap, assisted and prolonged by the opposition given to the air, by the membranous expansion between their limbs.

When a bird designs to fly, it first darts into the air, either by leaping from the ground, or by throwing itself from some height. In the mean time it raises the whole of the wings which had till then remained folded, and which it unfolds in a horizontal direction by extending the bones. When the wings have thus acquired all the superficial extent of which they are susceptible, they are suddenly depressed, till they form, with the vertical plane of the body, an angle that is obtuse upward, and acute downward. The resistance which the air gives to this motion suddenly performed in it, produces a reaction on the body of the bird, and thus moves it forward as in ordinary leaps. This impulse once given, the bird refolds the wings by bending the joints, and repeats its efforts by another stroke. As the velocity thus acquired in ascending is gradually diminished by the effect of gravitation, a moment occurs in which it ceases, and in which the bird tends neither to ascend nor descend. If at this moment it gives a new stroke with the wings, it acquires a new ascending velocity, by which it will be carried as far as before, and by repeating these efforts, it will ascend in a uniform manner. If this second stroke be made before the velocity first acquired is lost, an additional impulse will be received; and by a continuance of this action the bird will ascend with an accelerated motion. If the wings do not vibrate when the ascending velocity is lost, the bird will begin to descend; and if it allow itself to fall down to the point from which it set out, it cannot ascend as high as at first, but by a much stronger exertion of the wings; but if it seizes in the fall a point so situated that the acquired descending velocity, and the small space which it has to fall down reciprocally balance each other, it may, by a series of equal vibrations, keep itself at the same height.

When a bird wishes to descend rapidly, as when it darts upon its prey, it altogether suppresses the vibration of its wings, and thus falls by its own gravity. While descending, however, it may suddenly break its fall by extending its wings, and this suspension is called a *recover*.

We have as yet considered only the vertical flight of a bird. To fly horizontally, it must rise in an oblique direction, and make a new movement of its wings, when it is ready to descend below the point from which it departed; but in this way it will not fly in a straight line, but will describe a series of curves so very much depressed, that the horizontal will overcome the vertical motion. In order to ascend obliquely, the bird must make quicker vibrations of its wings, and to descend in a similar direction, the vibrations must be slower.

The deviations of flight to the right or left are chiefly produced by the unequal vibrations of the opposite wing; those of the left wing carrying the bird to the right, and *vice versa*. The more rapid the flight is forward, the greater is the difficulty of one wing surpassing the other in the velocity of its vibrations, and of course the deviation sideways is the more difficult. Hence birds which fly with the greatest velocity make large circles in turning.

The tail, when spread out, contributes to sustain the posterior part of the body. If it is depressed when the bird has acquired a progressive velocity, it presents an obstacle which elevates the posterior part of the body, and depresses the anterior. If it is turned up, the contrary effect is produced. Some birds incline to one side, to assist them like a rudder, when they wish to change their horizontal direction.

The structure of most birds peculiarly adapts them for rapid motion through the air, and for sustaining themselves in this element with the greatest facility. See ORNITHOLOGY, N° 37.

144 Swimming. The action of swimming, like that of flying, nearly resembles leaping, except that, like flying, the leap does not take place on a fixed surface. A great variety of animals, besides fish, and most of the other inhabitants of the waters, are capable of swimming. This action is performed with considerable ease by several of the mammalia,

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malia, even by the bulky elephant, and the unwieldly hippopotamus; by many tribes of birds; by several reptiles and serpents, and by some insects.

The organs employed by fishes, in making their way through the water, are their fins, tail, and air-bladder; the two former exerting the necessary motions like the wings of birds, while the latter, by being compressed or expanded, causes the necessary changes in the specific gravity of the body, and thereby renders the animal more or less buoyant. The swimming of fishes has been treated of with sufficient minuteness under ICHTHYOLOGY, chap. iii. sect. 3. to which we refer the reader.

The cetacea employ much the same means as fishes; but in them the principal efforts of the tail are made in a vertical direction, and the use of the air-bag is supplied by lungs, which they can compress and dilate at pleasure, by the action of the diaphragm, or the intercostal muscles. See CETOLOGY.

The swimming of mammalia, and of water birds, is performed by means of the legs and feet, which are used like oars, to propel the body forward by the resistance which they make to the water in the contrary direction. Hence those quadrupeds and birds that have flat or webbed feet, swim most easily, as the resisting surface is the greatest. Of all the mammalia, man has the most occasion to use his hands in swimming, on account of the greater proportional weight of his head.

Serpents, and the larvæ of such insects as sometimes inhabit the waters, perform the action of swimming by rapid inflections of the body like an eel or a leech. The larvæ that are most commonly found in the waters are those of the water *beetles*, the *hydrophilus*, the *day flies*, the *aquatic tipulæ*, and *gnats*.

145 No animal walks without legs, or flies without wings (if we except the flying fish, whose fins enable it rather to spring than fly); but there are many that swim without fins, and that leap and creep without any legs. The rapidity of movement is not proportioned to the number of instruments that are employed: if the spout-fish be observed to move slowly with one leg, the sea-urchin moves still more slowly with many thousands; the oyster moves by squirting out water; the scallop by the jerk of its shell, and when in the water it rises to the surface and sails before the wind.

Many animals are formed by nature to fly, walk, leap, and swim: the fate of those is rather uncommon whose muscles or feet are by nature attached to their integuments; the lobster is obliged to throw off its shell, and the caterpillar all its feet, with the skins, and in that situation to remain stationary till it receive new instruments of motion.

146 Whoever has read the celebrated work *De Motu Animalium*, needs not to be told that, besides the organs which are here mentioned, the form, the structure, and even the specific gravity of the body, as depending on the nature of the bones and muscles, or as varied by air-vesicles and bubbles, with a great variety of other circumstances, are necessary to explain the different phenomena of locomotion.

147 Vegetable motions.

As to vegetable motions, they evidently depend on external agents: the wings of seeds only fit them to be carried by the wind, their specific gravity to float in the water, and their legs or tentacula to adhere to bodies that are in motion; the singular motions which have been ascribed to sleeping, to waking, to sensation, and volition, in the vegetable kingdom, seem only the consequence of light, heat, moisture, and such stimulants, acting invisibly or with secret influence: the opening and closing of the meteoric flowers are always correspondent to the states of the atmosphere; and the opening and closing of the equinoctial and tropic flowers, to the light, the length or shortness of the day.

148 Uses of locomotion.

The principal intentions of locomotion are to get food, to shun danger, to promote intercourse and disperse the species.

There is perhaps no part of physiology which is more important than the relations which subsist between the different functions of the living body; but it is a part of the subject which is as yet but little understood. We regret that our limits will not permit us to pay all the attention to it which we could wish. We shall, however, briefly notice under each function, the principal relations that are found to take place between it and those which have been previously considered.

149 Mutual relations between sensation and motion.

Besides the dependence which animal motion has, in most instances, on the nervous system, (see N°111.) we find an evident sympathy between these two functions in a variety of phenomena. A violent emotion or impression on the nerves often throws the limbs into convulsive agitations; spasmodic affections are relieved, or sometimes removed, by the coming on of delirium; and these symptoms will alternate with each other: a compression of the brain, or of some large nervous trunk, produces general or partial want of motion, and when this compression is removed, the muscles for the most part recover their usual action; an attack of epilepsy is often preceded by the sensation of a stream of vapour commencing in some external part, and rising to the brain. These, and many other phenomena that might be mentioned, fully prove the sympathy between the nervous and muscular systems; and with this enumeration we must dismiss the subject.

CHAP. V. *Of Digestion.*

150 Appetite for food.

THE necessity of repairing the waste of the body is announced in all animals by the feelings of hunger and thirst; the former of which intimates the occasion for solid, the latter for liquid food. This imperious necessity overrules all the other affections of the vital principle, and every other appetite often remains suspended till that necessity be satisfied. It is difficult to assign the final cause of these singular sensations, but probably our researches on that subject are rather curious than useful. Whatever be the ultimate end of these appetites, we readily perceive how much they are influenced by habit. We find that when we are accustomed to take food at particular times, the appetite, under ordinary circumstances, always reminds us at these times, of the occasion, whether real or apparent, for receiving a new supply. By this influence of habit some animals, especially man, are accustomed to take several meals in a day, while others can fast for days, or even weeks, together. The appetite for food also varies considerably at different ages. It is more lively and more imperious in infancy and early childhood, and in general in those animals who have not yet acquired their full growth; it is on the contrary weaker in advanced age, and when the body ceases to increase:

Of Digestion. increase in size. It is more frequently renewed in the strong and healthy, and those who are accustomed to laborious occupations or active exercises.

151 We know that in the natural state of the animal body, the appetite for food is influenced by the nature of the aliment on which the animal is accustomed to subsist. Many animals live entirely on vegetable food, and these have no appetite for animal substances, and even reject these when offered to them. On the other hand, many tribes live entirely on animal food, and either refuse vegetable, or, if obliged by necessity to employ it as food, do not appear to derive nourishment from it. We find, however, that it is in the power of habit to remove these appetites; that a horse or a sheep may be taught to live on animal food, while a dog or a cat may be supported entirely on vegetable substances. A few animals are capable of subsisting on almost every kind of animal or vegetable substances, or are omnivorous.

152 Plants and some animals live on water and air alone. Many animals are capable of being supported by water and air alone. We know that several fishes, as the minow, the gold and silver fish, &c. will live for a long time in a vessel containing pure water, and freely exposed to the air. Rondelet (a celebrated writer on fishes in the 16th century) relates a remarkable instance of this. He kept a fish during three years in a vessel that was constantly full of very pure water. It grew to such a size, that at the end of that time the vessel could no longer contain it. Leeches are often kept for several years with no other nutriment but water, and that not very often changed. There is good reason to believe that the sole food of plants consists of water and air, and that the soil in which they grow answers scarcely any other purpose than that of preserving and conducting those necessary aliments.

153 It has been supposed that some animals are capable of subsisting on matters that appear to contain no nutritious principles, such as sand, hair, and wool. Borelli long ago conceived this opinion, from observing that in many testaceous animals which he dissected, the alimentary tube contained nothing but sand. It has often been remarked, that horses, cows, and sheep, when deprived of their usual nourishment, will lick their bodies, and swallow down the hair, or, in the case of sheep, will tear off and swallow each others wool. If we consider the nature of these substances, we think there is no reason to suppose that they answer any other purpose than distending the alimentary canal or stomach, and thus in some measure counteracting the effect of hunger.

The subject of food in general has been already treated of, under ALIMENT, and in MATERIA MEDICA, Part I. N° 17; and the function of digestion, as far as it relates to man, has been considered under ANATOMY, N° 106, 107, and under CHEMISTRY, N° 2548. It remains for us here only to make a few observations on the comparative physiology of this function.

154 Differences of digestion. Digestion differs considerably in the various classes of animals, both as to the organs by which it is performed, and as to the simplicity or complex nature of the operation itself. The general variations that take place in the organs of digestion, have been mentioned under the comparative part of ANATOMY, N° 152, and are fully treated of by Cuvier, in his *Leçons d'Anatomie Comparée*, tome iii, and Blumenbach, in his *Comparative Anatomy*, chap. 6. and 7.

In the more perfect animals, digestion supposes a series of operations, from the time that the food enters the mouth, till the nutritious parts of it are taken into the circulating system. These operations are, *mastication*, *insalivation*, *deglutition*, *chymification*, and *chylification*.

155 Mastication. *Mastication* is performed by means of teeth, and therefore can scarcely be said to take place in those animals that are not furnished with these organs. We know that all mammalia except those which Cuvier calls *edentata*, as the ant-eaters, pangolins, and platypus, have teeth, fitted both for dividing and chewing their food; but here an important difference takes place. Those animals which live chiefly on animal food, have most of their teeth sharp and pointed, for the purpose of seizing and tearing their prey, while the graminivorous and granivorous animals have very large and strong grinders, in which the hard substance commonly called enamel (or what Blake calls *corpus striatum*, *) forms alternate layers with the bony part. Such are also found in most reptiles and serpents, and in many fishes; but in some of these they seem less to serve the purpose of dividing the food, than to seize and retain it till swallowed. Birds have no teeth, though some of them have the mandibles of the bill so formed as to divide and cut in pieces their food.

* *Blake on the Structure and Formation of the Teeth.*

156 Insalivation. During mastication the food is mixed with the saliva, and is thus better fitted for easy solution in the stomach. This insalivation of the food may, however, take place, without previous mastication. It is common for serpents to swallow their food whole; but in order to facilitate its passage down the throat, they first besmear it all over with their mucous saliva. In many animals, a process similar to insalivation takes place, while the food remains in the mouth. In several species of the ape tribe there is a pouch situated on each side of the jaw, and in these pouches the greater part of the food is retained, not merely as some suppose, to serve as a future meal, but to undergo a dilution by the fluids that are there secreted. In granivorous birds, the food is first received into a membranous bag, formed by a dilatation of the gullet, and commonly called the *crop*, where it is macerated by the fluids that are there separated by means of glands or exhaling vessels, and passes down, as the animal requires, to be further prepared by the stomach. The bustard, indeed, though a granivorous bird, has no proper crop, but the gullet is furnished with numerous and large glands.

For an account of the chemical nature and properties of saliva, see CHEMISTRY, N° 2723.

157 Deglutition. The operation of deglutition depends chiefly on the action of the tongue, and on that of the muscles which surround the pharynx and gullet. It is more or less speedy in proportion as these are more or less active and vigorous. Most animals, after having once swallowed their food, do not receive it again into the mouth; but this takes place in several tribes, and is called *rumination*, or chewing the *cud*.

158 Rumination. Rumination takes place chiefly in those animals that feed on herbage, and have not a muscular stomach; such as all the tribes that Linnæus has ranked under the order *pecora*. In these the food, after being slightly chewed, is received into the first stomach, and after remaining there for a short time, it is gradually brought by a retrograde action of the gullet into the mouth, where it undergoes a complete trituration and insalivation,

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tion, and is then conveyed into the 2d, 3d, and 4th ſtomachs, to be mixed with the gaſtric juice.

Some of thoſe birds which have a diluting ſac or ingluvies, ſeem likewiſe to ruminate. This in the parrot was obſerved by the gentlemen of the French academy. It has ſince been obſerved in rooks, macaws, cockatoos, and others: and Mr Hunter, to whom phyſiology is ſo much indebted, diſcovered that the male and the female pigeon ſecrete in their ingluvies a certain liquor for feeding their young; and that moſt kinds of what have been thought ruminating birds do very often in expreſſing their fondneſs regurgitate their food. Yet both this and another ſpecies of regurgitation which is very common with thoſe animals that ſwallow indigeſtible ſubſtances with their food, ſhould be carefully diſtinguiſhed from rumination. For a farther account of rumination, and of the digeſtive organs of ruminating animals, ſee *Comparative* ANATOMY, N° 228—234. and *Phil. Tranſ.* 1807, Part ii.

159 Chymification.

The food having entered the ſtomach, undergoes in that organ proceſſes that are partly mechanical, or rather organic, and partly chemical, depending on the ſtructure of the ſtomach, and the nature of the juices ſecreted into its cavity. By theſe actions it is reduced into a pulpy ſubſtance commonly called *chyme*.

160 Organic action of the ſtomach.

The organic action of the ſtomach is greater or leſs, according as this organ is more or leſs muſcular. There are many animals, chiefly birds of the granivorous tribes, that have a very muſcular ſtomach, commonly called *gizzard*, capable of grinding, not only the grains received into it, but even of reducing to powder ſmall pieces of glaſs, and of blunting the points of needles and lancets. Theſe facts were firſt proved by Borelli, who introduced into the gizzards of fowls, nuts, filberts, hollow ſpheres of glaſs, hollow cubes of lead, ſmall pyramids of wood, and ſeveral other ſubſtances, which he found were either cruſhed together, or broken to pieces. He computes the power exerted by the ſtomach of the Indian cock as equal to the preſſure of 1350 pounds weight. Theſe experiments were repeated and verified by Spallanzani.

Some animals that are not poſſeſſed of a muſcular ſtomach have, within that organ, teeth, or other hard bodies, for the purpoſe of breaking or grinding their food. This is the caſe with many of the cruſtacea, as crabs and lobſters.

A great many animals have what Spallanzani calls *intermediate* ſtomachs, i. e. not ſo muſcular as the gizzard of fowls, nor ſo membranous as the ſtomachs of ruminating animals; this is the caſe with many birds, as ravens, crows, herons, &c. The ſtomachs of theſe animals are poſſeſſed of conſiderable force, though this is not nearly equal to that exerted by the gizzard. Theſe animals poſſeſs the power of rejecting by the mouth the ſubſtances that are incapable of digeſtion in the ſtomach, every nine, or ſometimes every three hours.

The animals with membranous ſtomachs are very numerous, comprehending man, moſt beaſts and birds of prey; many reptiles, ſnakes, fiſh, &c. The ſtomachs of theſe animals are ſuſceptible of but little muſcular action, though in many ſpecies they both contract upon the food, and reject it through the gullet, on various occaſions. Birds of prey, like the ravens, crows, &c. poſſeſs the power of rejecting, in the form of pellets, the indigeſtible parts of their food, which uſually takes place every 24 hours.

161 Diſcoveries of Mr Home.

A moſt intereſting paper by Mr Everard Home is publiſhed in the Philoſophical Tranſactions for 1807, part ii. on the ſtructure and functions of the ſtomachs of various animals. We regret that we can here give little more than the reſults of his inquiries.

From previous inveſtigations reſpecting the ſtomachs of ruminating animals, Mr Home was led to believe that the fourth ſtomach in theſe tribes was either always, or during digeſtion, divided into two portions, each performing a different office in the digeſtive proceſs; and he even conjectured, that a ſimilar diviſion might take place in other animals.

Mr Home has examined the ſtomachs of a great variety of animals, and inveſtigated the progreſs of digeſtion in *ruminants*, the *hare* tribe, which occaſionally ruminate, the *beaver*, *dormouſe*, *water-rat*, *common rat*, *mouſe*, *horſe*, and *aſs*, *kangaroo*, *pecaré*, *hippopotamus*, *elephant*, the *cetacea*, *fowls*, and laſtly in *man*.

162 Human ſtomach the link between carnivorous and phytivorous ſtomachs.

The human ſtomach appears to be the uniting link between thoſe that are fitted only to digeſt vegetable ſubſtances, and thoſe of animals that are entirely carnivorous; and yet we find, that in its internal ſtructure it is in every material reſpect ſimilar both to thoſe of the monkey and ſquirrel, which uſually digeſt only vegetable food, and to thoſe of carnivorous animals.

163 Into a *cardiac* and *pyloric* portion.

The human ſtomach is occaſionally divided into a *cardiac* and a *pyloric* portion, by a muſcular contraction ſimilar to thoſe of other animals; and as this circumſtance has not before been noticed, it is proper to be more particular in deſcribing it.

The firſt inſtance in which Mr Home obſerved this muſcular contraction in the human ſtomach, was in a woman who died in conſequence of being burnt, and who had been unable to take much nouriſhment for ſeveral days before her death. The ſtomach was found empty, and was taken out of the body at a very early period after death. It was carefully inverted to expoſe its internal ſurface, and gently diſtended with air. The contraction was ſo permanent, that after the ſtomach had been kept in water, in an inverted ſtate, for ſeveral days, and at different times diſtended with air, the appearance was not altogether deſtroyed.

Since that time, Mr Home has taken every opportunity of examining the human ſtomach ſhortly after death; and he finds that this contraction, in a greater or leſs degree, is very generally met with. He is of opinion that this effect is not produced by a peculiar band of muſcular fibres, but that it ariſes from the muſcular coat, in the middle part of the ſtomach, being thrown into action to a greater or leſs extent according to circumſtances. When this part of the ſtomach is examined by diſſection, its muſcular fibres are not to be diſtinguiſhed from the reſt. If the body be examined ſo late as 24 hours after death, this appearance is rarely met with; a circumſtance which accounts for its not having before been particularly noticed.

164 Food firſt diſſolved in the cardiac portion;

That the food is diſſolved in the *cardiac* portion of the human ſtomach, is proved by this part only being found digeſted after death; the inſtances of which are ſufficiently numerous to require no addition being made to them. This could not take place unleſs the ſolvent liquor was depoſited there. Mr Hunter goes ſo far as

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to say in his paper on this subject, "there are few dead bodies in which the stomach at its great end is not in some degree digested."

165 but the chyle formed in the pyloric portion.

That the chyle is not formed there, and that it is commonly formed before the food passes through the *pylorus*, is proved by the result of some experiments made by Mr Hunter upon dogs, in the year 1760. The dogs were killed while digestion was going on; and in all, the food was least dissolved, or even mixed, towards the great end of the stomach, but became more and more so towards the *pylorus*, just within which it was mixed with a whitish fluid like cream.

166 Solvent liquor secreted by glands near the gullet.

From the result of these experiments, as well as from the analogy of other animals, it is reasonable to believe, that the glands situated at the termination of the cuticular lining of the œsophagus, which are described by Mr Home, secrete the solvent liquor, which is occasionally poured on the food, so as to be intimately mixed with it before it is removed from the cardiac portion; and the muscular contraction retains it there, till this takes place.

167 Curvature of the stomach accounted for.

Such contraction being occasionally required in the stomach, accounts for its being more or less bent upon itself, as by this structure it is more readily divided into two portions, by the action of the muscular fibres at that part where the angle is formed.

This contraction also explains why the contents of the stomach are not completely discharged from the first effect of an emetic; and by it Mr Home thinks we may explain the cramp of the stomach, and some kinds of indigestion.

168 Ornithorinchus the real link between quadrupeds and birds.

After comparing the stomachs of several carnivorous animals with that of man; in tracing the gradation from carnivorous beasts through the bat tribe to birds of prey, Mr Home remarks that "the only real link between the stomachs of quadrupeds and birds is that of the ornithorinchus (or platypus), which, however, is more an approach to the gizzard, being lined with a cuticle containing sand, and having the same relative situation to the œsophagus and duodenum. The food of this animal is not known; it is probably of both kinds; the papillæ at the pylorus, which appear to be the secretory ducts of glands, are peculiar to it.

169 General conclusions.

From the facts and observations brought forward in this valuable paper, Mr Home deduces the following general conclusions. "That the solvent liquor is secreted from glands of a somewhat similar structure in all animals, but much larger and more conspicuous in some than in others.

"That these glands are always situated near the orifice of the cavity, the contents of which are exposed to their secretion.

"That the viscid substance found on the internal membrane of all the stomachs that were examined recently after death, is reduced to this state by a secretion from the whole surface of the stomach, which coagulates albumen. This appears to be proved, by every part of the fourth cavity of the calf's stomach having the property of coagulating milk.

"This property in the general secretion of the stomach leads to an opinion, that the coagulation of fluid substances is necessary for their being acted on by the solvent liquor; and a practical observation of the late Mr Hunter, that weak stomachs can digest only solid food, is in confirmation of it.

"That in converting animal and vegetable substances into chyle, the food is first intimately mixed with the general secretions of the stomach, and after it has been acted on by them, the solvent liquor is poured upon it, by which the nutritious part is dissolved. This solution is afterwards conveyed into the pyloric portion, where it is mixed with the secretions peculiar to that cavity, and converted into chyle.

"The great strength of the muscles of the pyloric portion of some stomachs will, by their action, compress the contents, and separate the chyle from the indigestible part of the food.

"In animals whose food is easy of digestion, the stomach consists of a cardiac and pyloric portion only; but in those whose food is difficult of digestion, other parts are superadded, in which it undergoes a preparation before it is submitted to that process."

170 Action of the gastric juice.

The action of the juices of the stomach, or of what we call the *gastric juice*, appears to have much more effect in the process of chymification, than the muscular action of the stomach, though the dissolving power of this fluid seems to be proportionally less in those animals that have the most muscular stomachs. The gastric juice of granivorous birds is capable of dissolving flesh; but when this is entire, it requires four or five days for solution; whereas when bruised, half that time is sufficient. Even grain is not dissolved in it except when bruised. The gastric juice of animals with intermediate stomachs dissolves flesh and cartilage, but not bone. It is incapable of dissolving entire seeds. In animals with membranous stomachs, the gastric juice is extremely active, and seems to be almost the only agent in the digestive process. In some of these animals, however, as the ruminating tribes, this fluid has no effect on the food, unless it be bruised, or thoroughly masticated. Spallanzani found, that owls digest flesh and bones, but not grain;—that the gastric juice of the eagle dissolves bread and bone, and even animal and vegetable matters, when it is taken out of the body;—that a wood pigeon may be gradually brought to live on flesh;—that the owl and falcon do not digest bread;—that the gastric juice of the dog dissolves even the enamel of the teeth.

Hence, in every order of animals, the gastric juice is the principal cause of digestion, and it agrees in all in many properties, and differs in others. In the frog, the newt, scaly fishes, and other cold-blooded animals, it produces digestion in a temperature nearly equal to that of the atmosphere. In warm blooded animals it is capable of dissolving the aliment in a degree of heat lower than that of these animals. In them too the food is digested in a few hours, whereas in the opposite kind it requires several days, and even weeks, particularly in serpents; likewise, the gastric juice of the gallinaceous class can dissolve only bodies of a soft and yielding texture, and previously triturated; whilst in others, as serpents, the heron, birds of prey, and the dog, it decomposes substances of great tenacity, as ligaments and tendons; and even of considerable hardness, as the most compact bone. Man belongs to this class, but his gastric juice seems to have no action on the hardest kinds of bones. Some species, likewise, are incapable of digesting vegetables, as birds of prey; but man, the dog, cat, crows, &c. dissolve the individuals of both kingdoms alike, and are omnivorous, and in general their gastric juices produce these effects out of the body.

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For an account of the chemical nature and properties of the gastric juice, see CHEMISTRY, N° 2551.

171 Solubility of foods.

The process of chymification depends also, in a great measure, on the nature of the substances employed as food, as some of these are much more soluble than others. On this subject much information may be derived by consulting the experiments of Dr Stark *, and those of M. Gosse of Geneva, an abstract of which is given in Johnson's Animal Chemistry, vol. i. p. 207. From the latter experiments it appears, 1*st*, That the following substances are either insoluble, or are not digested in the usual time in the stomach.

* Stark's Works.

Animal substances. 1. Tendinous parts. 2. Bones. 3. Oily or fatty parts. 4. Indurated white of egg.

Vegetable substances. 1. Oily or emulsive seeds. 2. Expressed oils of different nuts and kernels. 3. Dried grapes. 4. Rind of farinaceous substances. 5. Pods of beans and pease. 6. Skins of stone fruits. 7. Husks of fruits, with grains or seeds. 8. Capsules of fruit, with grains. 9. Ligneous stones of fruits. 10. The gastric juice does not destroy the life of some seeds; hence bitter-sweet, hemp, misletoe, and other plants which sometimes grow upon trees, are produced by the means of the excrements of birds, the kernels of seeds being defended from the menstruum by their exterior covering.

2*d*, That the following are partly soluble, viz.

Animal substances. 1. Pork dressed various ways. 2. Black puddings. 3. Fritters of eggs, fried eggs and bacon.

Vegetable Substances.—1. Salads of different kinds, rendered more so when dressed. 2. White of cabbage less soluble than red. 3. Beet, cardoons, onions, and leeks. 4. Root of scurvy-grass, red and yellow carrots, succory, are more insoluble in the form of salad than any other way. 5. Pulp of fruit with acids, when not fluid. 6. Warm bread and sweet pastry, from their producing acidity. 7. Fresh and dry figs. By frying all these substances in butter or oil they become still less soluble. If they are not dissolved in the stomach, they are, however, in the course of their passage through the intestines.

3*d*, That the following are soluble, or easy of digestion, being generally reduced to chyme in an hour, or an hour and a half.

Animal Substances.—1. Veal, lamb, and in general the flesh of young animals, are sooner dissolved than that of old. 2. Fresh eggs. 3. Cows milk. 4. Perch boiled with a little salt and parsley. When fried or seasoned with oil, wine, and white sauce, it is not so soluble.

Vegetable Substances.—1. Herbs, as spinach, mixed with sorrel, are less soluble. Celery. Tops of asparagus, hops, and the ornithogalus of the Pyrenees. 2. Bottom of artichokes. 3. Boiled pulp of fruits, seasoned with sugar. 4. Pulp or meal of farinaceous seeds. 5. Different sorts of wheaten bread, without butter, the second day after baking; the crust more so than the crumb. Salted bread of Geneva more so than that of Paris without salt; brown bread in proportion as it contains more bran is less soluble. 6. Rapes, turnips, potatoes, parsnips, not too old. 7. Gum arabic, but its acid is soon felt. The Arabians use it as food.

The solvent power of the gastric juice is increased by various stimulants, especially by those called *condiments*, as sea salt, spices, mustard, vinegar, as well as by vinous and spirituous liquors and old cheese in small quantities, and by various bitters. It is retarded by large quantities of diluting liquors, especially when taken hot; by acids and astringents taken a short time after eating; by unctuous substances; by mental employment, or severe bodily exercise, too soon after a meal; and by leaning with the breast against a table.

It may be proper here to notice the various opinions that have been entertained respecting the immediate cause of digestion. The principal of these opinions are, that it is produced by coction or heat; by trituration in the stomach; by fermentation, or by putrefaction. 172 Various theories of digestion.

That it is not brought about by heat alone, will appear from the circumstance, that many cold-blooded animals digest their food as completely, though not so expeditiously, as warm-blooded animals. 173 Heat.

That it is not effected by trituration in the stomach alone, is evident from the experiments that have been made by Spallanzani, Stevens, and others, of giving to animals food enclosed in hollow perforated balls, sufficiently strong to resist the muscular power of the stomach; as the balls have been found empty, and not compressed. 174 Trituration.

That it is not owing to fermentation is proved by the circumstance, that the more perfectly digestion proceeds, the less is the evolution of gases in the stomach; the contrary of which would be the case, if digestion consisted in a fermentation of the aliment. 175 Fermentation.

That it does not depend on putridity, is evidenced by the observations that have been made on putrid food given to dogs, and examined some time after, when it was found perfectly sweet. 176 Putridity.

On the whole it appears, that in most animals the digestion of food in the stomach depends partly on a due degree of heat, partly on the vital action of the stomach, but chiefly on the action of the gastric juice.

When the aliments have been converted in the stomach to the crude pulp called *chyme*, they are gradually propelled through the *pylorus* into the duodenum, where they are mixed with the bile, the pancreatic juice, and the fluids that are separated by the mucous coat of that intestine, and are thus reduced to a still finer pulp, containing, as one of its principal ingredients, the nutritious fluid called *chyle*, the nature and properties of which, as they have been but slightly mentioned in the former parts of this work, fall to be noticed here. 177 Chylification.

The properties of chyle have not been minutely investigated; but according to Fordyce, as far as experiment has been carried, the chyle of quadrupeds is so similar to that of man, and of each other, as hardly to be distinguished, even in tribes the most opposite to each other in their structure, food, and habits of life. As far as we can perceive, the chyle of a dog or a wolf differs in nothing from that of a sheep or an ox. 178 Properties of chyle.

The chyle consists of three parts; one part which is fluid, and contained in the lacteals, but coagulates on extravasation.

The second part consists of a fluid, which is coagulable by heat, and in all its properties hitherto observed, it is similar to the serum of the blood.

The third part consists of globules, which render the whole white and opake. These globules have been supposed by many to be an expressed oil; but this has not been proved. Neither has it been perfectly demonstrated that sugar is contained in the chyle, although it has been

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been made very probable. The difficulty of determining these points arises from the small quantity that can be collected, the largest animals not supplying more than one ounce or two, at the most. However, the part coagulating on extravasation; the part agreeing with serum in its qualities; the globular part, which in some animals, but not in quadrupeds, exists without giving whiteness to the chyle—alone, or along with sugar, form the essential parts of the chyle *.

* *Fordyce on Digestion*, 179

179 Progress of the chyle.

The compound pulpy matter containing the chyle is carried forward from the duodenum through the whole course of the intestines, where it is subjected to the continual action of the internal wrinkled membrane of the bowels, and its nutritious particles, or chyle, selected and absorbed by the lacteals that are abundantly distributed there, and open their mouths directly within the cavity.

180 Passage of food through the intestines.

As to the movements of the alimentary canal, the direction of hairs found in the stomach, and the balls of hairs which are thrown up, would appear to indicate a circular motion. The intestinal part has a motion similar to that of a worm, and is called the *vermicular* or *peristaltic*. Here every portion retains its own motion, although it be separated from the rest by ligatures. The stomach of the polype, the gullets of the ruminating kinds, and the cæca, have the motion in different directions at different times; and that observed in the alimentary canal of a louse is, when viewed through a microscope in the time of action, amazingly rapid; the stimulating causes employed are the food, the different liquors with which it is mixed, the air, the nerves where they exist, and a portion of heat. Some degree of heat is necessary to every process of digestion, both in the animal and vegetable kingdom; what that degree is depends on the nature of the living body; and is various according to its age, its health, its employments, and habits.

With respect to the function of digestion in the lower classes of animals, we can say but little. We know that their food is dissolved in the stomachs of the crustacea, of mollusca, and of polypes; but whether this process in most insects and worms is any thing more than imbibition, or taking in aliment, which is to undergo little change, we are uncertain. We know, indeed, that many insects live on substances which must be dissolved before they enter into the pores of their bodies, and that many of them abound in acrid juices, which are well fitted for this solution. It does not appear that plants possess what may be called the faculty of digestion.

181 Relations between digestion and sensation.

The relations between digestion and the functions we have already considered, especially sensation, are various and important. The sympathies that exist between the head and the stomach, have been long acknowledged. Several affections of the brain are accompanied with sickness at the stomach, loss of appetite, and indigestion; while, on the other hand, the deranged state of the digestive organs seldom fails to produce giddiness, headach, ringing in the ears, confusion or depravation of sight, &c.; and if the former symptoms arise to a great height, as in the case of overloaded stomach or surfeit, coma, or even apoplexy, is frequently produced. In many nervous affections, particularly hysteria and hypochondriasis, in which there frequently takes place astonishing accumulations of air in the stomach and bowels, the affections of the head, such as stupor, confusion of thought, partial blindness, &c. sometimes proceed to such a height, as to threaten, or even sometimes to produce, an apoplectic paroxysm. In many cases these affections are referred immediately to the head; but are proved, in most instances, to depend on the disordered state of the alimentary canal, from the immediate relief procured by those remedies which promote the discharge of air, or produce copious evacuation from the bowels. On the other hand, in some diseases, where the head is primarily affected, as in phrenitis hydrocephalica (water in the head), the complaint is referred to the bowels, from the costiveness or other disordered state of these. The daily experience of literary men shows how much intense thought diminishes the digestive powers, and how imperfectly studious occupations can be carried on after a full meal. The action of the digestive organs is also considerably influenced by the mind, or the passions. We know how readily the appetite may be diminished or destroyed by sudden anger or affliction.

The action of the stomach may even be influenced by the will. We have known a person who could vomit whenever he pleased; and Dr Darwin speaks of another who had acquired this voluntary command over the inverted motions of the stomach and throat, to such a degree, as to gain a subsistence by exhibiting these unnatural powers to the public. At these exhibitions he was accustomed to swallow a pint of red rough gooseberries, and a pint of white smooth ones; to bring them up in small parcels into his mouth, and restore them separately to the spectators, who called for red or white, as they pleased, till the whole were redelivered *.

* *Zoonomia*, vol. i. p. 276.

The sympathies that take place between the brain and the digestive organs, are easily explained, from considering the distribution of the great sympathetic nerve, to illustrate which we have given a figure (fig. 1.) showing its course and distribution from the head through the chest, as far as the stomach. Plate CCCCXVIII.

182 Relations between digestion and motion.

The relations between the digestive and the locomotive functions, are not less obvious. Experience shews how much digestion depends on regular exercise, and how imperfectly it is carried on in the stomach of the indolent and sedentary; while, on the other hand, when the stomach is overloaded, voluntary motion becomes difficult and fatiguing. Spasmodic contractions of the muscles, twitchings of the limbs, and similar affections, are the common attendants of indigestion, though these may perhaps be referred equally to the nervous as to the muscular system.

183 Morbid affections of digestion.

The principal morbid affections of digestion are, nausea, flatulence, eructation, rumination (G), vomiting, heartburn,

(G) That ruminating power which is natural to the quadrupeds of the order *Pecora*, is sometimes met with in man. We have heard of persons who regularly brought up their food into the mouth soon after eating, chewed it over again, swallowed the juices with the saliva, and spat out the more solid parts. In these cases, the rumination is

Of Absorption. heartburn, water-brash or *pyrosis*, loss of appetite, and inordinate appetite; for an account of which, see the article MEDICINE.

CHAP. VI. *Of Absorption.*

184 Absorption. WE have said that the chyle is taken up from the compound pulpy matter composed of the food and the animal juices, as it passes through the intestines, by the lacteals. This, however, is not the only absorption that takes place in the animal body. The fluids poured out into cavities by the exhalant arteries, as well as all the secreted or exuding fluids, and even the solid materials of the system, are taken up by the lymphatics, and carried into the circulation; the blood poured out into cells in some parts, is evidently absorbed by veins; and, as we shall endeavour to prove, an absorption takes place over the external surface of the body.

185 Organs. What is called the absorbent system, is composed, in the superior animals, of the *lacteals*, the *mesenteric glands*, the *thoracic duct*, the *lymphatics*, and the *lymphatic glands*. For an account of these in man, see ANATOMY, Part I. Sect. 14. This system, in a greater or less degree, is found in all animals, except some mollusca, insects, worms, and zoophytes. See Cuvier's *Leçons*, tom. iv. leç. xxiii. and Blumenbach's *Comparative Anatomy*, chap. xiii.

186 By lacteals and lymphatics. The action of the lacteals and lymphatics is probably much the same, and is exerted in a similar manner. That of the lacteals is to convey the nourishing parts of the food into the circulating system; that of the lymphatics to carry to the same system watery fluids, for the purpose of diluting the blood, and such fluid or solid materials as are useless, or may prove noxious to the system. The action of the lacteals may be readily seen on opening an animal killed two or three hours after eating; and in this way they were first seen by Asellius. They are then found filled with a milky fluid, while, at other times, they are invisible. That the lymphatics are the principal organs of absorption, is now the general opinion of all physiologists, though their action in this way can seldom be demonstrated. As, however, it has been satisfactorily proved, that the veins do not in general absorb, and as the lymphatics that proceed from parts that contain irritating matters, are often seen inflamed, proving that they have imbibed a part of the irritating matter, there is little doubt that the office of absorption belongs almost exclusively to the action of the lymphatics.

187 By the veins. Mr John Hunter made several experiments to shew that the veins do not absorb. He conveyed milk, coloured with various dyeing substances, or perfumed with musk, into the small intestines of an ass, which was soon after killed. On opening the veins of the intestines, and allowing the blood to separate into serum and crassamentum, the serum was found neither to be tinged with the colouring matters, nor scented by the perfume, while the coloured milk was evident in the lacteals. That the veins, however, do in some cases perform the office of absorbents, is evident from the speedy depletion of the *corpora cavernosa penis*, after having been distended with arterious blood; and from a similar depletion that takes place in the nipple of the female breast.

188 By the skin. The principal object in dispute respecting the function of absorption in man and the higher classes of animals, is, whether the skin possesses the power of absorption. This question, as it is both curious and important, we shall examine pretty much at large; and for this purpose we shall avail ourselves of an able paper on the subject, by Dr George Kellie.

It had long been received as an established truth, that the skin was an inhaling or an absorbing organ, and that sometimes the inhalation balanced, or even surpassed, the exhalation of the cutaneous surface; but of late this doctrine of inhalation has been called in question, and, in the opinion of many, entirely overthrown. It has been said, that this absorption neither does nor can take place on the outside of the cuticle; that in every case of apparent absorption, the *epidermis* had been injured, or that the matter absorbed had been mechanically forced through it, and brought into immediate contact with the skin.

Haller had asserted *, on the authority of Default, that the body acquired an increase of weight in the warm bath; and this augmentation of weight was esteemed an *experimentum crucis* in favour of cutaneous absorption.

Experiments, however, have since been made with every necessary care, which seem to contradict the position, and to prove, that the body acquires no additional weight in the warm bath.

Seguin, from a great many experiments of this description, concludes, that there is no inhalation, because the body, so far from gaining, always lost some part of its weight during immersion, although much less than in the air in equal times †.

In other experiments again, as in those of Gerard and Currie, there was no increase of weight; but the body was

* *Elementa Physiologiæ*, tom. v. p. 88.

† *La Med. Eclairée.*

is to be considered as a disease, depending on the inability of the stomach to propel the solid food into the duodenum.

Mr Home, in the paper we have already quoted, (N° 161—169), relates a curious instance of habitual rumination in a man 19 years of age, who is blind, and has been an idiot from his birth. He has a very ravenous appetite, and it is necessary to restrict him in the quantity of his food, since, if he eats too much, it disorders his bowels. Fluid food does not remain on his stomach, but comes up again. He swallows his dinner, which consists of a pound and a half of meat and vegetables in two minutes, and in about 15 minutes he begins to chew the cud. Mr Home was once present on this occasion. The morsel is brought up from the stomach with apparently a very slight effort, and the muscles of the throat are seen in action when it comes into the mouth; he chews it three or four times, and swallows it; there is then a pause, and another morsel is brought up. This process is continued for about half an hour, and he appears to be more quiet at that time than at any other. Whether the regurgitation of the food is voluntary or involuntary, cannot be ascertained, the man being too deficient in understanding, to give any information on the subject.

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was not observed to have lost any thing during immersion in the warm bath.

Now, during these experiments, the body was doubtless wasting, by the pulmonary and cutaneous discharges, and yet the weight of the body either continued unchanged; or where a loss of weight was observed, this was constantly less, greatly less, than is experienced during the same interval in air. And we might be inclined to infer, from a truth so general, and so well ascertained, an argument in favour of absorption.

It might be argued, that the loss of weight amounts to little or nothing, because, during immersion, the body acquires more by inhalation than it does or can do in the air; that the loss by the pulmonary and cutaneous discharges is counterbalanced, or nearly counterbalanced, by the increased absorption.

Those, however, who deny absorption, will not allow us the advantage of this argument. They tell us, that the exhalation by the skin and lungs is diminished, which sufficiently explains why the body loses less in the warm bath than in air. But that the accustomed discharges are suppressed or diminished in the warm or tepid bath, is, we apprehend, far from being proved; and, till this proposition is made good, the argument against cutaneous inhalation cannot be securely maintained.

One of Dr Currie's cases deserves farther consideration. We allude to the case of dysphagia, published by this gentleman ‡, in which Mr M. the subject of the case, was several times immersed in a warm bath of milk and water, and was weighed when taken out. Mr M. it is true, gained no weight while in the warm bath; but the loss continually going on in the air was, as in other trials, suspended during the immersions. Besides, he always expressed great comfort from the bath, with abatement of thirst; and, subsequent to the daily use of it, the urine flowed more plentifully, and became less pungent. An observation, precisely similar, is made by Mr Cruickshank. "A patient of mine (says Mr Cruickshank), with a stricture of the œsophagus, received nothing, either solid or liquid, into the stomach for two months; he was exceedingly thirsty, and complained of making no water. I ordered him the warm bath for an hour, evening and morning, for a month; his thirst vanished, and he made water in the same manner as when he used to drink by the mouth (H) *.

‡ *Medical Report*, first edit. p. 227.

* *Cruikshank on the Absorbents.*

But to return to the case of Mr M——. Dr Currie himself remarks, that the discharge by urine alone exceeded much in weight the waste of his whole body; and it cannot be doubted that the discharge by stool and perspiration exceeded the weight of the clysters.—Thus it appears, that the *egesta* exceeded the *ingesta* in a proportion much greater than the waste of his body will explain. How is this accounted for, Dr Currie asks, unless by cutaneous absorption?

That the excess of these discharges above the *ingesta* and total waste, can be accounted for by absorption only, was indeed an irresistible conclusion. Still, however, cutaneous absorption is denied; and, when forced to confess, that there are cases where the *egesta* exceed the *ingesta* in a much greater proportion than the waste of the body will explain, and which can only be accounted for by absorption, they refuse this function to the skin, and bestow it most liberally, and, in so far as we know, most gratuitously, on the lungs. We are not entitled, in return, to deny the reality of pulmonary absorption, but we may surely be allowed to urge, that there is no proof that the only inhaling organ is in the lungs; and there is none against the possibility of cutaneous absorption.

Is it not, on the other hand, proved, by the experiments of Seguin and Lavoisier, that the exhalation greatly exceeds the absorption by the pulmonary system? And if this is always the case, we cannot explain by pulmonary inhalation alone, why the *egesta* should, in some cases, exceed the *ingesta* in a much greater proportion than the waste of the body will account for.

We now proceed to examine another class of experiments, much insisted on by those who deny cutaneous absorption; we mean those experiments performed by immersing a part of the body in solutions of active drugs, the absorption of which should be indicated by their usual effects on the system.

Seguin made numerous experiments of this kind, with solutions of muriate of mercury (corrosive sublimate), on syphilitic patients. And we are informed, that in cases where the epidermis was perfectly sound, neither the known effects of mercury on the body, nor any amelioration of the venereal symptoms, was ever observed.

He also immersed his own arm in a solution of two drams of the mercurial muriate in ten pounds of water. At the temperature of 10° and 28° Reaumur, no part of the salt was missing at the end of the experiment; but when the bath was at 18° of the same scale, there was a loss of one or two grains of the muriate in the hour, though the quantity of fluid was not diminished.

The explanation given by Seguin of this unexpected result is curiously ingenious, but embarrassed, and inconsistent.

At the temperature of 12°, he observes, the exhalants are in a state of contraction, and their orifices nearly closed. When the heat again is raised to 26°, the exhalation is so rapid, that nothing can enter the vessels from without; but at 18° of temperature, the orifices of the exhalants are sufficiently relaxed, and the exhalation at the same time so conveniently languid, that the solution rests quietly in contact with the matter of perspiration in the mouths of the exhalants, where it is somehow or other decomposed; a part of the salt leaving the water of solution, and combining with the perspirative matter, with which it is carried into the system *. Carried into the circulation by the exhalants! Is not this a plain acknowledgment of the reality of inhalation? But if in one case substances may thus be carried into the circulation, why not in many others?

* *La Méd. Eclairés*, tom. iii. p. 238.

Surely if the weight continues undiminished, in circumstances

(H) That thirst may be allayed by immersion in water, is fully proved by the experience of shipwrecked mariners, who, when obliged to take to their boats with very little fresh water, frequently have recourse to bathing in the sea, or covering themselves with a shirt wetted in salt water, and thus quench their thirst, nearly as well as if they had drunk fresh water.

Of Abſorption.

cumſtances where the body is continually loſing, we may infer, that ſomething has been gained by abſorption. And where the egeſta exceed the ingeſta in a proportion much greater than the waſte of the body will explain, there abſortion muſt have been going on.

The caſe of Mr M——, publiſhed by Dr Currie, is not ſingular. The writings of phyſicians abound in ſimilar examples. They had often occurred to that excellent clinical practitioner De Haen, who was therefore perſuaded that water was imbibed †. Haller too, with his uſual induſtry, has collected a great many obſervations of the ſame kind ‡.

† *Ratio Medendi*, part iv. chap. 3.

‡ *Elem. Phyſiol.* tom. v. p. 90.

Again, when phyſicians were engaged in their extenſive ſtatical experiments, weighing themſelves, their *ingeſta* and *egeſta*, for many months, nay for years together; they ſometimes obſerved, that ſo far from loſing, they had gained weight, eſpecially during cold and moiſt weather. Thus, Rye, under a cold and humid atmoſphere, gained 13 ounces. Linnings, during two hours expoſure to cold, acquired 8½ ounces. The abbé Fontana, after two hours expoſure to a moiſt atmoſphere, returned home ſome ounces heavier than he went out. De Gorter gained 6 ounces in one night; and on other occaſions, two ounces and four ounces. Theſe obſervations are confirmed alſo by the experience of Dr Francis Home, profeſſor of Materia Medica in the univerſity of Edinburgh. 'Having fatigued myſelf pretty much (ſays he) in the afternoon, I went to bed without ſupper, and was ſo hungry that I could not fall aſleep for ſome time. Betwixt eleven at night and ſeven next morning I had gained two ounces ‡.'

‡ *Medical Tracts and Exper.* p. 250.

Here then are examples of the body gaining conſiderably more than the *ingeſta* will account for, acquiring weight when neither food nor drink had been ſwallowed. And we have the concurring teſtimony of the moſt reſpectable writers ſupporting the ſame truth.

How can this increaſe of weight be accounted for, unleſs by abſorption? In ſuch experiments, the *loſs of weight*, which cannot be accounted for by the ſenſible *egeſta*, is attributed to the exhalation; the increaſed weight ſometimes obſerved, and which cannot be explained by the ſenſible *ingeſta*, muſt in like manner be referred to the *inhalation*.

That the ſyſtem may be affected by active medicines introduced and abſorbed by the ſkin, cannot be denied. And were proofs ſtill wanting to eſtabliſh the doctrine of cutaneous abſorption, this argument might be inſiſted on. It is true, that friction is commonly employed when we wiſh to introduce medicines by the ſkin, by which, it is ſaid, the ſubſtance is mechanically forced through the cuticle, and brought into contact with the abſorbents of the true ſkin. The ſyſtem, however, may be affected without friction, for example, by wearing a mercurial plaſter, and more certainly by mercurial fumigation, as practiſed by Lalonette and others *.

* *Edinb. Med. and Surg. Jour.* vol. i. p. 181.

It might even be concluded from an examination of the ſtructure of the ſkin, that abſorption muſt take place at its ſurface. We know that the cuticle is porous, and is penetrated by exhaling veſſels; we know that lymphatics commence immediately below it; and we know that when certain ſubſtances are applied to the cuticle, eſpecially when this application is aided by moderate friction, as in the caſe of applying garlic poultices to the feet, and the more familiar inſtance of mercurial inunction, that theſe ſubſtances are taken up by the abſorbents, and conveyed into the circulation.

From a conſideration of all theſe circumſtances, we think it fully proved, that the ſkin is an abſorbing or inhaling organ. For further proofs we may refer our readers to Bichat's *Anat. Gener.* tom. iv. p. 691.

189 Suppoſed retrograde action of the lymphatics.

Mr Charles Darwin, ſon of the late Dr Darwin, publiſhed in 1780, a Latin theſis, which is tranſlated in the 29th ſect. of his father's Zoonomia, vol. i. in which he attempts to prove, that the valves of the lymphatics are ſo formed as in particular caſes to admit of the regurgitation of the abſorbed fluids. The arguments on which he founds this opinion (beſide the difficulty of accounting for the phenomena of ſeveral diſeaſes on any other principle), are chiefly the following:

Firſt, The mouths of the lymphatics ſeem to allow water to paſs through them after death, the inverted way, more eaſily than in the natural direction.

Secondly, In ſome diſeaſes, as diabetes and ſcrofula, it is probable the valves themſelves are diſeaſed, and are thence incapable of preventing the return of the fluids they ſhould ſupport.

Thirdly, There are valves in other parts of the body analogous to thoſe of the abſorbent ſyſtem, which are liable, when diſeaſed, to regurgitate their contents.

Fourthly, The capillary veſſels, which muſt be conſidered as analogous to abſorbents, may be ſeen, in animals ſubmitted to the microſcope, to regurgitate their contents into the arteries, during the ſtruggles of the dying animal.

By means of this hypotheſis (for notwithſtanding the arguments adduced in its favour, we can call it no better), Mr Darwin explained the ſpeedy paſſage of watery fluids from the ſtomach to the urinary bladder; the phenomena of diabetes; diarrhœa, dropſy, cold ſweats; tranſlations of matter, chyle, milk, and urine; the operation of external remedies, &c.

190 Abſorption in the loweſt claſſes of animals.

In all thoſe claſſes of animals that poſſeſs a complete abſorbent ſyſtem, the phenomena of abſorption ſeem to proceed much in the ſame manner as in man; but in ſome of the inferior animals, eſpecially in molluſca and worms this function ſeems to be performed by the veins *. In the *echinodermata*, however, eſpecially in the ſea-urchin (*echinus eſculentus*), lymphatics have been demonſtrated by the ſecond Monro. In inſects and polypes there is no proper abſorption.

* *Cuvier Leçons*, tom. iv. p. 161.

191 Abſorption of plants.

The abſorbing veſſels of plants are chiefly the fibrils of the roots, which evidently imbibe moiſture, and perhaps gaſeous fluids, from the earth; but there have alſo been demonſtrated veſſels opening beneath the outer bark, which botanical phyſiologiſts conſider as lymphatics. "Lymphatic veſſels (ſays Wildenow), are found in the epidermis of plants, and are of great minuteneſs, anaſtomoſing in various ways through ſmall intermediate branches." They ſurround the apertures of the cuticle, by which the inhalation and exhalation of vegetables are carried on; but they are ſo minute as not to have yet been filled with coloured liquids. Round each opening, which is commonly ſhut by a moveable valve, they form a circle, rarely a rhombus, as in the *zea mays*. In the *lilium calcedonicum*, thoſe veſſels run obliquely, and ſomewhat in an irregular undulating manner, fig. 2. In the common onion (*allium cepa*), they run in a ſtraight, though oblique and regular form, fig. 3. In the pink, (*dianthus*

Plate CCCCXVIII.

Of Absorption.

(*dianthus caryophyllus*), they are very ſtraight, with ſtraight and horizontally tranſverſe branches, fig. 4. In almoſt every plant they have their certain and peculiar direction, which in each remains conſtantly the ſame *.

* *Wildenow's Princ. of Bot.* ſect. 236.

192 Theory of abſorption.

The theory of abſorption is ſtill but imperfectly underſtood. We ſhall briefly notice the principal hypotheſes that have been brought forward to account for the entrance of ſubſtances into the mouths of the abſorbing veſſels; for this part of the proceſs alone ſeems to be diſputed.

It was long the opinion of phyſiologiſts, that fluids enter the mouths of the abſorbents on the principle of capillary attraction; but as the abſorbing veſſels are not circumſtanced like rigid capillary tubes, immerſed in a fluid; and as, were this hypotheſis juſt, abſorption ſhould go on with regularity, and all fluids ſhould be abſorbed indiſcriminately, neither of which circumſtances is true; this hypotheſis is now generally abandoned.

Mr John Hunter accounted for the entrance of ſubſtances into the mouths of the abſorbents, by attributing to the mouths of theſe veſſels a power of nibbling, ſimilar to that exerted by a caterpillar when feeding on a leaf. This opinion may be called ingenious, but is certainly very wild and fanciful.

Dr Fullarton, in a theſis on abſorption, publiſhed at Glaſgow in 1800, attributes to the abſorbing orifices, a power of ſuction ſimilar to that of the proboſcis of butterflies, and the tentacula of ſome marine animals.

The firſt and third of theſe hypotheſes ſuppoſe the abſorbents incapable of taking up any but fluid ſubſtances; but we well know that even the hardeſt bones are ſomehow abſorbed, and conveyed to the circulation. We muſt therefore add another hypotheſis, which ſuppoſes that there is ſecreted in the animal body, a fluid capable of diſſolving fleſh and bones †. The hypotheſis, however, is without foundation. It is contrary to the ſimplicity of the animal economy, that there ſhould take place, firſt, a ſecretion of ſolid matters to compoſe the ſtructure of the body, and then a ſecond ſecretion to diſſolve them. We muſt therefore conſider this part of phyſiology as a ſubject of future inveſtigation.

† *Duncan's Med. Com.* vol. x. p. 354.

When the abſorbed ſubſtances have once paſſed the barrier of the firſt valve, it is not difficult to account for their further progreſs through the lymphatics. A continual ſucceſſion of freſh abſorbed matter muſt drive forward what is already in the veſſels, while the valves muſt in general prevent its reflux. The impelling force from behind is alſo probably aſſiſted by the irritability of the veſſels. It is not ſo eaſy to decide how the abſorbed matters paſs through the glands, if, as is generally believed, they do not in theſe form continuous tubes, there muſt be a freſh abſorption by the mouths of the veſſels that paſs out of the gland, which is as difficult to account for as the firſt reception at the origin of the veſſels.

193 Relations of abſorption with the preceding functions.

The relations that take place between abſorption and the preceding functions, are perhaps the leaſt underſtood of any that occur in the animal economy. We know that the action of the abſorbents is greatly aſſiſted by muſcular motion, and that it is in general moſt defective in indolent and ſedentary perſons. An evident ſympathy is alſo obſerved between the ſtomach and the abſorbents. Nauſea, and eſpecially vomiting, are powerful promoters of abſorption, and ſome remarkable inſtances are related of the ſpeedy abſorption of a large quantity of purulent matter from an abſceſs, in conſequence of violent vomiting.

Of Circulation.

Chap. VII. *Of Circulation.*

194 Circulation.

We have traced the nutritious particles of the food from the inteſtines through the *lacteals*, the *meſenteric glands*, and the *thoracic duct*, into the left *ſubclavian vein*, where we find the chyle is mixed with the venous blood, and carried to the right auricle of the heart. We muſt now conſider how the fluids are conveyed to every part of the body, or we muſt examine the function of *circulation*.

195 Organs.

This function takes place in all the vertebral animals, and in molluſca, worms, and cruſtacea; but there appears to be no real circulation in inſects, zoophytes, and plants.

The organs by which circulation is performed differ eſſentially in the ſeveral claſſes of animals. Thoſe of the human ſyſtem have been deſcribed in the firſt part of Anatomy, ſect. x. and xi. and a brief comparative view of theſe organs in the inferior animals, has been given in the ſecond part of that article, N° 154, 201—204, 300, &c. and in the articles Cetology, Erpetology, Ichthyology, and Ornithology. For a fuller account of theſe latter, we may refer to Cuvier's *Leçons*, leç. xxiv and xxv. and to the Comparative Anatomy of Blumenbach, chap. xii.

196 Pulmonic and ſyſtemic parts.

It is well known that, in the red-blooded animals, the blood is not of the ſame ſhade of red in every part of the body; but that what has paſſed through the lungs, and is circulating through the arteries that proceed from the aorta, is of a florid red colour, while that which is ſent to the lungs by the pulmonary artery, as well as that which is returning from the extremities of the arteries through the veins, is of a purple or crimſon colour. As one ſet of organs always contains florid, and another ſet always crimſon blood, it is convenient to diſtinguiſh each ſet by an appropriate name. Dr Barclay has done this, and he calls that ſet of organs which are employed to convey the blood from the arteries, and diſtributed to the lungs, *pulmonic*, compriſing the *pulmonic veins*, viz. the vena cava and its branches, *pulmonic auricle*, *pulmonic ventricle*, and *pulmonic arteries*: while he denominates that ſet of organs which return the blood from the lungs, and diſtribute it to the ſyſtem, *ſyſtemic*, comprehending the ſyſtemic veins (pulmonary veins), ſyſtemic auricle, ſyſtemic ventricle, and ſyſtemic arteries, (the aorta and its ramifications). One great advantage of this nomenclature, is that it prevents the ambiguity of the expreſſions *right* and *left*, *anterior* and *poſterior*, applied to the auricles and ventricles of the heart. We ſhall therefore employ them in the ſubſequent part of this chapter *.

* See *Barclay on Muſcular Motions*, p. 231.

For an account of the nature and properties of the blood, ſee Anatomy, Part I. ſect. 14. and Chemistry, N°. 2642.

197 Proofs of the circulation of the blood.

It may not be improper, in this chapter, to notice the principal arguments that have been uſed to prove the circulation of the blood. They are as follow:

1. When an artery is tied, the part of the artery that is betwixt the ligament and the heart, ſwells; but that part of it which is betwixt the ligature and the remote branches, becomes more flaccid than before. On the other hand, when a vein is tied, the part between the ligature

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2. The valves placed at the mouths of the aorta and pulmonary artery, must prevent the blood from regurgitating into the ventricles, while they permit it to flow forward through the arteries, into the capillary branches of the veins. Again, the valves situated in the course of the veins prevent the blood from flowing back into the arteries, while they permit it to proceed forward through the venous trunks into the heart.

3. By the assistance of a microscope, the blood may be seen in the pellucid parts of animals, as the feet of frogs, flowing from the arteries into the veins.

4. When an artery of moderate size is wounded, and not secured by ligature or compression in proper time, the blood flows out till the animal be dead.

5. Any thin liquid, when injected into an artery, does not pass backwards into the heart, but flows forward into the inosculating veins. On the other hand, such a liquid thrown into a vein, flows towards the heart, and not into the smaller branches of the vein.

The phenomena of circulation in the human body have been already mentioned under ANATOMY, sect. xii. and xiii. and under MEDICINE, N° 95. We shall here only offer a compendious view of the course of the blood in the adult and in the fœtal state.

198 Circulation in the adult man.

I. After birth, the blood coming from every part of the body through the numerous ramifications of the vena cava, is poured into the right or pulmonic auricle of the heart, by the contraction of which it is thrown into the right or pulmonic ventricle, which contracting, throws it into the pulmonary artery, being prevented from regurgitating into the auricle by the action of the tricuspid valves. It is now, by means of the ramifications of the pulmonary artery, distributed through the lungs, from which it is brought back by four principal pulmonary veins, and poured into the left or systemic ventricle, which contracting with great force, propels it into the aorta, it being prevented from regurgitating into the auricle by the action of the mitral valves. The blood being propelled into the aorta, is by its trunks and branches, distributed to every part of the body, and brought back as before by the ramifications and trunks of the *vena cava*.

199 Circulation in the human fœtus.

II. In the fœtal state, the blood being brought back from every part of the body by the ramifications and trunks of the vena cava, is poured into the pulmonic auricle of the heart, where it is mixed with the blood brought from the placenta. A part of this blood is conveyed from the sinus of the auricle while in a state of dilatation, through the oval hole, into the systemic auricle; while another part, by the contraction of the auricle, is thrown into the pulmonic ventricle, which contracting, propels it into the root of the pulmonary artery. From this the greater part of the blood passes through the arterious canal, that in the fœtus joins the pulmonary artery to the aorta, into this latter; while the remainder is distributed by the ramifications of the pulmonary artery to the lungs, and brought back by the pulmonary veins to the systemic auricle of the heart. By the contraction of this auricle, the blood is thrown into the systemic ventricle, which contracting, propels it into the aorta. Now, while one part of the blood is distributed by the numerous ramifications of the aorta to every part of the body of the fœtus, another part is carried from the internal iliac arteries, through the two umbilical arteries, into the placenta, from which it is conveyed through the umbilical vein to the sinus of the liver. Hence, one part of the blood, without entering the liver, is transmitted by a branch of the umbilical vein, called *venous duct*, into the left branch of the *vena cava hepatica*; thence into the inferior great vena cava; while another part, by another branch of the umbilical vein, flows into the left branch of the *vena porta*, by the numerous ramifications of which it is distributed to the liver. From the liver it is carried by the *venæ cavæ hepaticæ* into the inferior great *vena cava*, whence it is conveyed with the rest of the blood, to the pulmonic auricle of the heart, to be distributed as before.

200 Powers carrying on the circulation.

We must now briefly consider the powers by which the blood is made to circulate through such a multitude of vessels, so infinitely ramified, and differing so much in their diameter. It seems generally allowed at the present day, that these powers are chiefly the immediate muscular action of the heart, the action of the arteries, the valves of the veins, and the pressure produced on some of the veins by the action of the muscles that lie contiguous to them.

201 Action of the heart.

1. That the heart must possess very considerable force in propelling the blood through the arteries, may be supposed from the great muscularity of its ventricles; and this force has been proved by experiment and observation. From experiments made by Hales, viz. that of inserting a glass tube into a large artery, and measuring the height to which the blood ascends at each pulsation, it has been calculated, that the human carotid artery is capable of projecting its blood to a perpendicular height of seven feet and a half; and if we estimate the surface of the systemic ventricle at 15 square inches, we shall find that it sustains a pressure of 1350 cubic inches, equal to 51 pounds weight, which it has to overcome by its contracting force *. This is a moderate computation of the force of the heart, for Borelli estimates it at 180,000 pounds, while Keill diminishes it to eight ounces. Senac again, from having observed, that if a weight of 50 pounds be attached to the foot, with the knee of that side placed over the opposite knee, the weight will be raised at each pulsation, and allowing for the distance at which the weight is placed from the centre of motion, computes the force of the heart at 400 pounds †. Blumenbach has seen the blood projected from the carotid of an adult more than five feet ‡. On a medium calculation, estimating the quantity of blood contained in the body at 30 pounds, the number of pulsations in each minute at 75, and the quantity of blood ejected from the systemic ventricle at each contraction at two ounces and a half, we shall find that the whole 30 pounds of blood will be carried through the whole body no less than 23 times in an hour, or the circulation will be completed in less than three minutes. From these circumstances we must infer that the impelling power of the heart is very great, and fully adequate to the office which it has to perform.

* Hales's *Statical Essays*, vol. ii.

† *Traité du Cœur.*

‡ *Institutiones Physiolog.*

Various hypotheses have been formed to explain how the heart and arteries are excited to motion, but our limits will not permit us to detail them. Our readers will find them related at considerable length, and fully examined in the *Principes de Physiologie* of Dumas, tom. iii.

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iii. p. 332—364. The general opinion at present entertained on this subject is, that the heart is excited to action by the stimulus of the blood.

202 Action of the arteries

2. Although it is more than probable that the action of the heart is the principal instrument in carrying on the circulation, there can be no doubt that the arteries contribute essentially to this office. They are evidently muscular, and are possessed of considerable irritability; are supplied with numerous nervous filaments, and are nourished by small arterial branches, commonly called *vasa vasorum*. Nay, we know that they are susceptible of contraction; for when we divide an artery in the living body, the divided extremities gradually contract, till, if the animal is not killed by the experiment, the aperture is at length obliterated*. Lastly, there have been instances of fœtuses without a heart; and as we must suppose that, during the life of the fœtus, the circulation was going on, it is a natural inference that this was chiefly effected by the contraction of the arteries, and not entirely by the impelling power of the circulating system of the mother.

* *Hunter on the blood*, p. 114.

203 Valvular structure of the veins.

3. It cannot be supposed that the veins have any immediate action on the blood, as they exhibit no circular fibres like the arteries, except in the immediate vicinity of the heart; but their valvular structure must contribute to the carrying on of the circulation, from the opposition it gives to the return of the blood, so that what is called the *vis à tergo*, or impelling power from behind, aided by the conical form of the veins, may have its full effect.

204 Action of the muscles.

4. That the action of the muscles has considerable influence in propelling the blood towards the heart, in those veins that lie in their neighbourhood, is evident from the effect that bodily exercise produces in accelerating the circulation, and from the efficacy of friction in removing congestions of blood in the veins of the extremities, and in the more familiar instance of promoting the swelling of the veins of the arm by the same means in the operation of bleeding.

205 Circulation of the inferior animals.

The circulation in those animals whose structure approaches to that of man, differs little from what is above described. There are indeed some peculiarities, a few of which we shall presently notice. An account of the circulation in the cetacea will be found in the article Cetology, N° 140—145, that of the reptiles is described under Erpetology, page 309.

206 Circulation of the mollusca.

The mollusca possess an evident and powerful circulation. Most of them have a simple heart, consisting of one auricle and one ventricle; and in these the vena cava performs the office of an artery, carrying the returning blood to the gills, whence it passes to the auricle, and is afterwards thrown into the aorta. There is a peculiarity in the cuttle fish, which has a heart consisting of three ventricles, without any part that can properly be called an auricle. Two of the ventricles are placed at the roots of the two bronchiæ, and have each a branch of the vena cava, by which they receive the blood from the body, and propel it into the bronchiæ. The returning veins open into the middle ventricle, and from this the aorta proceeds.

207 in the vermes;

Some of the vermes, as the leech, and the tribes of the *naias*, *nereïs*, and *aphroditæ*, and some species of *lumbricus*, have no heart, but they have circulating vessels with evident contraction and dilatation.

208 in crustacea.

In the *crustacea*, the circulation is performed by a single ventricle, expelling the blood into the arteries of the body, and receiving it again after it has passed through the gills, in a manner very similar to the circulation of fishes.

209 Contracting and dilating tube in insects.

There is no circulation in insects; but these animals have running along the back a membranous tube, in which alternate contractions and dilatations are perceptible. This tube, however, is closed at both ends, and has no vessels proceeding from it.

210 No circulation in plants,

From the researches which evince circulation to be a function so general among animals, some are disposed to think it takes place in all living bodies. But notwithstanding the fashionable language of circulating fluids, of veins, arteries, and even of valves, in the vegetable structure; yet nothing performing the office of a heart, and nothing that seems to conduct fluids in a circular course, has been found in plants. In the vegetable kingdom, the chyle is distributed to all the parts, from the numerous vessels which convey the sap; and these vessels, being fitted by their structure to carry the sap either downwards or upwards, from the branches to the roots, or from the roots to the branches, is the reason why plants inverted in the ground will send forth roots from the place of their branches, and send forth branches from the place of their roots. Even a similar distribution of the chyle takes place in some animals. In the human tænia, in the *fasciola hepatica* (fluke) of sheep, and in most polypes, the chyle, without a circulating system, is conveyed directly to the different parts from the alimentary canal. 211

211 nor in some animals.

For an account of the motion of sap in plants, see Darwin's *Phytologia*, a paper by Mr Knight in the *Philosophical Transactions* for 1801, Wildenow's *Principles of Botany*, sect. 276, and the article Plant in this Encyclopædia.

212 Relations between circulation and sensation.

The relations that subsist between the function of circulation, and those which we have already considered, are very important. We shall begin with those of circulation and sensation. That the functions of the nervous system must be considerably influenced by the circulation of the blood, may be supposed *à priori*, from the large quantity of blood sent to the head, this being, on a moderate calculation, about one-tenth of the whole. A certain quantity of blood in the vessels of the brain seems essential to the due performance of the functions of that organ; and those animals, which, like man, have the blood sent in greatest quantity, and with greatest impulse, seem to possess the faculties of the brain in the greatest perfection, while those in whom the motions of the blood towards the head is much retarded, as in the sheep and cow, are remarkable for mildness and stupidity. When, however, the quantity of blood becomes too great, or its impetus too violent, the faculties of the brain are impaired, or altogether destroyed. No man, and very few other animals, can remain suspended with the head downwards for any long time, without dangerous, and commonly fatal consequences. The bat, indeed, is a remarkable exception to this rule, for this animal can hang by its hinder feet for days or weeks together, with perfect safety, a circumstance that may be accounted for from the very small quantity of blood contained in its circulating vessels. Again, the brain exerts an evident influence on the circulation. It is well known how much the action of the heart and arteries is quickened, impeded, or rendered irregular, by the

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the passions of the mind. Cases are recorded in which these passions, carried to excess, have altogether stopped the circulation, and produced instant death. Fainting is often brought on by the sight of a disgusting or terrifying object, or by the odour of perfumes, or of substances to which the person has a particular antipathy. The sympathy between the heart and the nervous system is farther shown by the violent pain below the *sternum*, and sometimes in the arm, in cases of organic disease of the heart.

The circulation is even affected by intense thought; and we have heard of a bleeding from the nose being brought on by long and deep study, while the body was in a reclining posture, namely in bed.

213 Relations between circulation and motion.

The functions of circulation and motion are intimately related. It is scarcely necessary to notice the acceleration of the pulse, in consequence of exercise and labour, or to remark that in indolent and sedentary people the circulation is generally slow and languid. In general, too, the blood circulates with most rapidity in those animals who are formed for quick motion, though the instance above quoted, of the bat, shows that the quickness of motion does not depend on the quantity of blood. Several curious anatomical facts have rendered it probable, that the production of quick or slow motion depends in a great measure on the mode in which the arterial branches are distributed to the moving organs. The arterial branches that supply the organs of voluntary motion, are divided in such a manner as to impede the motion of the blood towards these organs as little as possible: their ramifications are therefore few, and they go off from the trunk at very acute angles; whereas those that supply the viscera are at nearly right angles, are often tortuous, and are otherwise so constructed as frequently to impede the flow of blood. Physiologists have even explained the greater power that is generally found in the right arm, and the greater readiness with which most people use that arm, by the manner in which the right subclavian artery comes off from the aorta. This indeed we are disposed to consider as fanciful, and to attribute the more ready use of the right arm solely to habit and early instruction not to employ the left.

214 Distribution of the arteries in the limbs of slow-moving animals.

In some animals that are remarkable for slowness of motion, as the *lemur tardigradus*, or slow lemur, and the *bradypus tridactylus*, or common sloth, there is a curious construction of the arteries that are distributed to the limbs of these slow-moving animals, which must have the effect of breaking the force, and impeding the velocity of the blood towards these limbs. In the *lemur tardigradus*, a specimen of which was dissected by Mr Carlisle, it was found that the *subclavian artery* and the *external iliac* were, soon after rising from the general trunk, divided into a great number of equal-sized cylinders surrounding the principal artery, now diminished to a very small size, and that each of these branches was sent to each of the principal muscles of the limbs, while the other arteries that supplied the other parts of the limbs were divided in the usual arborescent form. Struck with this appearance, Dr Shaw and Mr Carlisle afterwards examined several specimens of the sloth, and found a similar conformation, while in other species of bradypus, not remarkable for slow motion, no such appearance took place *. Fig. 5. & 6. Plate CCCCXVIII. represent the division of the arteries in the slow lemur above described.

* *Shaw's General Zoology, vol. i.*

The relations between the circulating and digestive organs are proved by the sudden acceleration of the pulse from stimuli received into the stomach; from the diminished circulation or sudden cessation of the heart's motion from powerful sedatives received into the same organ, especially the *prunus lauro-cerasus*; from the irregularity produced in the circulation in consequence of *dyspepsia*, and many other considerations.

215 Relations of circulation with digestion.

216 Relation of circulation and absorption.

That there is an intimate relation between circulation and absorption, cannot be doubted, though the nature and effects of this relation are not yet well understood. We know that the vessels sympathize with the absorbents in their activity or languor; that when the absorbents are languid in their action, the blood-vessels, especially the exhalants, are in a feeble or relaxed state, and that the absorbents are often roused to greater action by remedies that first act on the circulation.

217 Action of the vessels on the blood.

Numerous experiments have shown how much the colour and consistence of the blood are altered by the mere action of the vessels; and this discovery has enabled us to conjecture with more probability than we did formerly, why in infants and phlegmatic persons the blood is paler, in the choleric more yellow, and in the sanguine of vermilion red. It explains likewise in some measure, why the blood varies in the same individual, not only with regard to the state of health, but likewise at the same instant; and why the blood which circulates through the veins has not the same intensity of colour, nor the same consistence, as that of the arteries; and why the blood which flows through the organs of the breast differs from that which passes languidly through the viscera of the lower belly. This power of the vessels over the blood will bring us also to the true cause why the vessels vary in the density of their coats and in their diameters; why they are sometimes convoluted in a gland, and why they sometimes deposit their contents in a follicle; why they are sometimes of a spiral form; why the branches strike off at various angles; why they are variously anastomosed; why they sometimes carry the blood with dispatch, and sometimes slowly through a thousand windings. By these means their action is varied, and the blood prepared numerous ways to answer the ends of nutrition and secretion.

On the varieties of the *pulse*, and the morbid affections of circulation, see Medicine, N° 96—104.

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218 Necessity of respiration.

While the fluids are passing through the body, by what is called the *greater circulation*, they give out certain parts or principles, partly for the purpose of nutrition, and partly to free the system from noxious matters. In order to regain some of the principles which they have lost, it is necessary that they should be exposed to the influence of atmospheric air; for which purpose they are made to pass through appropriate organs, which, as we have already observed, are in general either lungs or gills. The action by which the fluids and the air are made to act on each other, is called *respiration*, and consists of two kinds, *inspiration*, by which the air is received into the body, and *expiration*, by which it is again thrown out.

So essential is respiration to the system, that snails, chameleons, and some other animals, can live for years, without any apparent nourishment, provided they be not excluded

excluded from air. We have ſeen a chameleon that lived, and was vigorous, for 22 months, without any food, and which might have continued to live much longer, but for an unfortunate bruiſe by a fall.

Other phenomena equally demonſtrate the importance of air to the living body. The frog leaps away wanting its heart; it ſurvives the loſs of the greateſt part of its ſpinal marrow; without its head, it lives for ſome days, and its heart continues to circulate its blood. Borelli found, that eels and ſerpents, though their bodies be opened, and the whole of their bowels be taken out, are able to move for a day after, and yet, in all theſe animals, the life is obſerved to be ſuddenly extinguiſhed when the all-vivifying air is excluded. Even the ſmalleſt inſect has died, and the plant loſt its vegetative power, when retained for any conſiderable time in a vacuum. Fiſhes themſelves, when placed under an exhauſted receiver, have ſtarted anxiouſly to the ſurface of the water in queſt of freſh air; and finding none, have ſunk to the bottom and expired in convulſions. It will preſently appear that this neceſſity of air to life is general in all the claſſes of organized beings (K).

219 Organs.

The organs of reſpiration belonging to the human ſyſtem, viz. the *larynx*, windpipe, lungs, diaphragm, ribs, and numerous muſcles, have been ſufficiently deſcribed in various parts of the article ANATOMY; and ſome account of theſe organs in the inferior animals has been given in the ſecond part of that article, N° 155, 156, 206, 208, 271—274, and in the articles CETOLOGY, ERPETOLOGY, and ICHTHYOLOGY. For a more complete account of the reſpiratory organs in the inferior animals, the reader is referred to Cuvier's *Leçons d'Anatomie Compareé*, Leç. xxvi. et xxvii. and to Blumenbach's *Comparative Anatomy*, chap. xiv. and xv.

220

In examining the function of reſpiration in warm-blooded animals, two circumſtances are principally to be conſidered; the mechaniſm of reſpiration, or the mechanical means by which the organs are enabled to receive and expel the air, and the effects produced by reſpiration on the circulating fluids, and on the ſyſtem at large. Our principal object in this article is briefly to explain the mechaniſm of reſpiration; to notice the effects produced on the air by the reſpiration of different animals, with the effects produced on them, and the relations that take place between reſpiration and the preceding functions of ſenſation, motion, digeſtion, and circulation.

221 Mechaniſm of reſpiration in man.

In order to make an inſpiration, the intercoſtal muſcles, and the muſcular fibres of the diaphragm, are thrown into contraction, while at the ſame time the abdominal muſcles, and the muſcular fibres of the windpipe, are relaxed. By theſe means the diaphragm being drawn towards the *ſacrum*, and rendered leſs convex towards the cheſt, and the ribs being drawn upwards (or forwards in quadrupeds), the cavity of the cheſt is enlarged, and the air remaining in the lungs being rarefied, the external air ruſhes in through the windpipe by its own gravity, and diſtends the lungs. In making what is called a very deep inſpiration, other muſcles that are connected with the atlantal ribs, viz. thoſe called *ſcaleni*, *trapezii*, *cervicales deſcendentes*, *ſerrati ſuperiores*, and pectoral muſcles, aſſiſt to elevate the ribs more than in an ordinary inſpiration. By the action of the intercoſtal muſcles the ribs are drawn *atlantad* (upwards in man, and forwards in quadrupeds), becauſe the moſt atlantal rib on each ſide of the thorax is fixed, and therefore all the other ribs are drawn towards it; and they are alſo drawn peripherad (outwards), becauſe their greater curvature is in the direction of the *ſacrum*, and becauſe they turn on their vertebral extremities as on a fulcrum.

In order to make an expiration, the abdominal muſcles, and the muſcular fibres of the windpipe, are contracted, while the intercoſtal muſcles, and the muſcular fibres of the diaphragm are at the ſame time relaxed. By theſe means, aided by the elaſticity of the cartilages of the ribs, and perhaps of the mediaſtinum, the ribs are drawn ſacrad (towards the ſacrum), while the diaphragm, partly by its own muſcular action, and partly in conſequence of the preſſure of the bowels, is rendered convex towards the cheſt. Thus, this cavity is conſiderably diminiſhed, the lungs are compreſſed, and part of the air is expelled through the windpipe. In making a ſtrong expiration, little more is neceſſary than a more powerful contraction of the abdominal muſcles.

222 In other animals.

The mechaniſm of reſpiration in mammalia is ſo ſimilar to that of man, that we need not enter into it; that of *cetacea* has been ſufficiently explained under CETOLOGY, N° 146—151; that of birds may be gathered from what has been ſaid on their ſtructure, in the comparative part of ANATOMY, N° 271, and in ORNITHOLOGY, N° 37; that of reptiles has been fully explained under ERPETOLOGY, page 311; and that of fiſhes under ICHTHYOLOGY, page 73. The mechaniſm of this function in the claſſes of animals below theſe is ſo ſimple, that a conſideration of it is unneceſſary. In inſects the air enters the numerous ramifications of the *tracheæ*; is carried by them into every part of the body, and is then returned by the ſame paſſages. In ſome of the molluſca, reſpiration proceeds in a ſimilar manner, by the ramifications of the pulmonary veſſels that enter by the neck; but in moſt of theſe, and in all the loweſt tribes, ſuch as worms and zoophytes, reſpiration ſeems to be carried on entirely by the pores of the ſkin.

223 Quantity of air received and emitted.

Many attempts have been made to aſcertain the quantity of air received and emitted in a ſingle inſpiration or expiration. See CHEMISTRY, N° 2535. This point is not yet fully aſcertained, but we may probably eſtimate the quantity expelled by each ordinary exſpiration at one-ſeventh part of the whole contents of the lungs, and that of the moſt violent expiration at about four-ſevenths

(K) It was long ago obſerved by Pliny, that if the bodies of inſects are beſmeared with oil, they ſoon periſh: "*oleo illito inſecta omnia exanimantur*." The ſame obſervation was afterwards made by Ray, who explained it by ſhowing that in this way the pores through which the animals breathe are ſtopped. Mayow alſo found, that if the oil be applied only to ſome of theſe pores, the neighbouring parts become paralytic, while the reſt of the body continued ſound. See Ray's *Wiſdom of God*, and Mayow's *Tractatus*.

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sevenths of that quantity; or that the medium quantity of air consumed during a common inspiration or expiration is about 40 cubic inches *.

* Bostock on Respiration, p. 35.

224 Ordinary number of respirations in a minute.

Another circumstance respecting the mechanism of respiration merits notice, viz. the ordinary number of respirations made in a minute by a healthy person. This varies considerably in different subjects, being in general greatest in children, and least in old persons. Dr Hales estimated the number of 20 in a minute; the subject of Dr Menzies' experiments respired only 14 times in the same period, while Mr Davy reckons his respirations at between 26 and 27; the subject of the experiments made by Messrs Allen and Pepys, breathed about 19 times in a minute, and with this Dr Thomson's experience agrees. The average of all these is about 20, which we may probably consider as a tolerably just estimate. Much, however, will depend on the circumstances in which the person is placed; on his habits of activity or indolence, of temperance or intemperance; on the state of the atmosphere, &c.

225 Experimental writers on respiration.

The chemical changes produced on the air by the respiration of animals have been described, so far as they were then known, under CHEMISTRY, N° 2536. Since that article was written, however, several valuable observations have been published, and the most important of these must be here noticed; but as we cannot, in this place, give any thing more than a summary sketch of these observations, we shall here enumerate the principal works that have appeared on this experimental part of our subject. The chemical physiologists who have been most conspicuous in these researches are, Mayow (in his *Tractatus de Respiratione*, or the *Analysis* of his works by Beddoes); Priestley (*Experiments and Observations on Air*); Lavoisier (*Traité Elementaire de Chimie*, *Physical and Chemical Essays*, and a work on *Atmospheric Air*); Goodwyn (*On the Connection of Life with Respiration*); Coleman (*On Suspended Respiration*); Menzies (*On Respiration*); Spallanzani (*Memoires sur la Respiration*, translated into French by Senebier, and since into English, and *Rapports de l'Air avec les Etres Organisés*, &c. also collected by Senebier); Davy (*Researches Philosophical and Chemical, into the Nature of Nitrous Oxide*; Ellis (*Inquiry into the Effects produced on Atmospheric Air by Respiration*), and Allen and Pepys (*Philosophical Transactions*, 1808, Part II. or *Phil. Mag.* vol. xxxii.). Most of the facts observed by these experimentalists, except those of the three last mentioned, have been collected by Dr Bostock, in his *Essay on Respiration*, by Dr Thomson in his *System of Chemistry*, vol. v. third edition, and by Mr Johnson in his *Animal Chemistry*, vol. iii.

226 Ascertained changes on respired air.

The following changes produced on air that has been respired by warm-blooded animals, seem to have been fully ascertained; viz. 1. That the respired air generally suffers a sensible diminution of bulk; 2. That it loses a part of its oxygenous portion; 3. That it acquires an additional quantity of carbonic acid gas; 4. That it is charged with watery vapour. We shall resume these facts, and consider the additional information which has been acquired respecting them since the publication of our article CHEMISTRY.

227 Its volume sensibly diminished.

1. *Atmospheric air generally suffers, by the respiration of warm-blooded animals, a sensible diminution in its bulk.*—The results of the experiments made by different chemists on the diminished volume of respired air, are exceedingly various. Mr Davy makes the diminution amount to one-eighteenth † of the whole air inspired; Lavoisier and Goodwyn estimate it at no more than one-sixtieth ‡, and Dr Bostock so low as one-eightieth ||, while Crawford and some later experimentalists could perceive no diminution. Dr Thomson states the results of his experiments upon this subject to be, that in some cases he could perceive no diminution at all, while in others it was perceptible. It was greatest when the animal was taken out repeatedly during the experiment, or when he employed air purer than that of the atmosphere. He is disposed to consider the diminution as accidental, and as owing to some absorption of air, altogether independent of respiration, and exceedingly various in different circumstances §. In the experiments of Messieurs Allen and Pepys, the general average of the deficiency in the total amount of common air inspired, appeared to be very small, amounting to about six parts in 1000, and they are inclined to attribute it, in a great measure to the difficulty of exhausting the lungs so completely after an experiment as before it *.

† Researches, p. 435.
‡ Bostock on Respiration, p. 87.
|| Ib. p. 99.
§ System of Chem. third edit. vol. v. p. 735.
* Philos. Mag. vol. xxxii.

228 Part of its oxygen abstracted.

2. *Atmospheric air, by the respiration of warm-blooded animals, loses a part of its oxygen.*—From a comparison of the experiments of Mr Davy, with those made by Lavoisier just before his death, Dr Thomson estimates the quantity of oxygen consumed in a minute, by respiration, at 31.6 cubic inches, making in 24 hours 45,504 cubic inches; and he concludes that in a day a man consumes rather more than 25 cubic feet of oxygen, and that he renders unfit in the same time, for supporting combustion and respiration, no less than 125 cubic feet of air †.

† System of Chemistry, vol. v. p. 736.

229 Carbonic acid gas acquired.

3. *Atmospheric air acquires, by respiration, an additional quantity of carbonic acid gas.*—The opinion of Dr Menzies, that the bulk of carbonic acid gas produced by respiration, is precisely equal to that of the oxygen lost, appears now to be fully confirmed. In Mr Davy's experiments they corresponded very nearly ‡, and in those of Mr Dalton and Dr Thomson, they corresponded exactly. The latter chemist found, on the whole, that the bulk of oxygen which disappeared was somewhat greater than that of the carbonic acid generated; but the difference varied considerably, and kept pace with the diminution of the bulk of air respired. Hence he considers it as owing to the abstraction of part of the air by some other way than respiration, and allowing for this abstraction, he has no doubt that the bulk of the carbonic acid formed is precisely equal to that of the oxygen that has disappeared. He is disposed to consider the absolute quantity of carbonic acid generated in 24 hours, as something less than 40,000 cubic inches on an average ||. The following results of the experiments made by Messieurs Allen and Pepys, as these were made on a large scale, may be considered as quite satisfactory on this head. 1. It appears that the quantity of carbonic acid gas emitted is exactly equal, bulk for bulk, to the oxygen consumed. 2. Atmospheric air once entering the lungs, returns charged with from 8 to 8.5 per cent. carbonic acid gas, and when the contacts are repeated almost as frequently as possible, only 10 per cent. is emitted. When the inspirations and expirations are more rapid than usual, a larger quantity of carbonic acid is emitted in a given time; but the proportion is nearly the same, or about eight

‡ Researches, p. 431.
|| System Chem. vol. v. p. 737.

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eight per cent. The proportions of carbonic acid gas, in the first and last portions of a deep inspiration, differ as widely as from 3.5 to 9.5 per cent. 3. It appears that a middle-sized man, aged about 38 years, and whose pulse is 70 on an average, gives off 302 cubic inches of carbonic acid gas from his lungs in 11 minutes; and supposing the production uniform for 24 hours, the total quantity in that period would be 39534 cubic inches, (*agreeing almost exactly with Dr Thomson's estimate*) weighing 18,683 grains, the carbone in which is 5363 grains, or rather more than 11 ounces troy; the oxygen consumed in the same time will be equal in volume to the carbonic acid gas; but it is evident, that the quantity of carbonic acid gas emitted in a given time, must depend very much upon the circumstances under which respiration is performed; and here it may be proper to notice, that all these experiments were made between breakfast and dinner. 4. A larger proportion of carbonic acid gas is formed by the human subject, from oxygen than from atmospheric air *.

* *Phil. Mag.* vol. xxxii. p. 265.

230 Watery vapour acquired.

4. *Atmospheric air returns from the lungs charged with aqueous vapour.*—Of this circumstance there is no doubt, but the quantity of water contained in the expired air, and the sources from which it is derived, are still in dispute. Dr Thomson estimates the former at about 19 ounces per day; but he does not lay much stress on the results of his own experiments, as they were not sufficiently varied to give a fair average. As to the sources of this watery vapour, it has been generally supposed, that the water is formed in the lungs by a combination of part of the oxygen consumed with hydrogen evolved from the venous blood. This, however, is mere hypothesis. It has not been proved that hydrogen is evolved from the blood; and as the quantity of oxygen consumed appears to be taken up in forming the carbonic acid gas that is expired, there is none left to form water. No hydrogen, or any other gas, except carbonic acid and azotic gas, appear to be evolved during the process of respiration †.

† *Phil. Mag.* xxxii. p. 269.

231 Is azote lost?

There is another change supposed by most chemical physiologists, to be produced on the air by respiration, namely the loss of part of its azote; but this is still disputed. Dr Bostock concludes it to be probable, that a small portion of azote is lost, which he estimates on an average at $\frac{1}{100}$ of the air respired, making in 24 hours, about 4.5 ounces, or four cubic feet ‡. Mr Davy found the consumption of azote to amount to about one seventh of that of oxygen ‖; and some late experiments of Dr Henderson afford a similar result, though in these the proportion is rather less §. Dr Thomson also found a loss of azote, but it was extremely inconstant, sometimes being scarcely perceptible, at others considerable. It kept pace with the diminution of the bulk of the air respired, and with the difference between the bulk of the oxygen consumed, and the carbonic acid formed. He conceives that a portion of the air respired disappears without undergoing any change, and that this portion occasions the diminution of the azote, and the difference between the bulk of the carbonic acid formed, and that of the oxygen consumed. He thinks it conceivable, that the disappearing of such a portion may be confined to the unnatural circumstances occasioned by the experiment; that the difficulty of throwing out the air from the lungs in these circumstances, may be such as to induce absorbents to act, and remove a portion which in the ordinary state of the lungs would have been thrown out by expiration *.

‡ *Essays on Respiration*, p. 100.
‖ *Researches*, p. 433.
§ *Nicholf. Jour.* 8vo. vol. viii. p. 44.
* *Syst. Chem.* vol. v. p. 738.

232 Changes on the air by the respiration of the inferior animals.

Experiments on the changes produced on atmospheric air and oxygenous gas, by the respiration of the inferior animals, have been made chiefly by Vauquelin, Spallanzani, and Mr Davy, and some of them have been repeated and varied by Mr D. Ellis. From all these experiments we find, that, by the respiration of amphibia, of fishes, of insects, of mollusca, and of worms, the air in which they have been confined suffers changes analogous to those produced in it by the respiration of the warm-blooded animals; that the oxygenous part is diminished, and that this diminution is most complete when insects and worms have been confined in it; that carbonic acid gas is in all cases produced, but that the quantity produced varies in different animals, that fishes live for the shortest time, and amphibia and worms for the longest, when confined in a certain quantity.

From the latest experiments made by Spallanzani, on the effects both of living and dead animals, on atmospheric air, as collected by Senebier, that experimentalist has drawn the following conclusions. 1. In beginning with worms, and rising up to man, there is no species of animal which does not destroy the oxygen of the atmosphere after death, and destroy it entirely if it be kept inclosed in it, provided the quantity be not too great in proportion to the size of the animal; because a considerable time is required when the volume of air is large, and a less time when the quantity is small.

2. This destruction of oxygen by dead animals, is under similar circumstances slower than that effected by living animals, if we regard merely the effects produced by the cutaneous organ, independent of the action of the lungs.

3. He thought he had legitimately proved, that the destruction of oxygen by the cutaneous organ, is not occasioned by the combination of this gas with the carbone of the animal; but that it is a true absorption of that element, by the body of the animal deprived of life. It does not give out carbone, but carbonic acid, as he believed he had proved by unanswerable experiments.

4. The absorption of oxygen by animals cut into small pieces, is greater than that occasioned by animals entire in similar circumstances.

5. A cold-blooded animal of the same bulk, and in the same circumstances as a warm-blooded animal, absorbs more oxygen than the latter after death.

6. The skin is not the only part of an animal which absorbs oxygen; all the parts, solid, fluid, and soft, not excepting the driest horny parts, as the nails of quadrupeds, the bill and feet of birds, produce the same effect †.

† *Edin. Med. Jour.* vol. v. p. 109.

233 Effects of vegetation on the air.

It has long been known that plants would not vegetate, if excluded from atmospheric air. Papin confined an entire plant in the exhausted receiver of an air-pump, and it soon perished; but on keeping a similar plant in this vacuum, with only its leaves exposed to the air, it continued to live for a long time ‡. When the leaves of a plant are stript off, or blighted by insects; when they have the upper surface smeared with oil, with varnish, or laid upon water §, the plant dies in a few days. Hence it is evident that the leaves of a plant are necessary organs, and that there is produced on the air in which

‡ *Darwin's Phytologia*, p. 51.
§ *Ellis's Inquiry*, p. 28.

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which the plant vegetates, ſome change eſſential to the healthy action of the plant. What this change is, has not been fully aſcertained. It is the general opinion, that the leaves abſorb a portion of the atmoſphere, and give out certain gaſeous products; and it is generally believed, that moſt plants have the property of giving out oxygenous gas during their expoſure to the light, and azotic gas or ſome other irreſpirable air in the dark. That oxygenous gas is neceſſary to vegetation, is fully proved; and it ſeems certain, eſpecially from the experiments of Mr Ellis, that under the ordinary circumſtances, carbonic acid gas is generated during their vegetation *. Mr Ellis, who is not ſatisfied with the accuracy of the experiments of Scheele and Prieſtley, ſeems to doubt whether plants at any time give out oxygenous gas; and thinks that the principal uſe of oxygen to them, is to combine with the ſuperfluous carbone produced by vegetation, and thus form the carbonic acid evolved.

* *Ellis's Inquiry*, p. 39. *et ſeq.*

234 Effects of reſpiration on the animal ſyſtem.

Having conſidered the effects produced on the air by the reſpiration of animals, and the vegetation of plants, we muſt now notice the effects produced by the exerciſe of the ſame function on the animal body, as the compariſon of theſe effects with the changes produced on the air itſelf, affords us the only clue to a rational theory of reſpiration.

235 Changes on the blood.

We have already ſtated (CHEMISTRY 2540), that during reſpiration, the blood changes from the dark colour which it has in the veins, to the bright ſcarlet of arterial blood. It has been found, that a clot of venous blood, when out of the body, aſſumes the bright tinge, when expoſed to the action of oxygenous gas; and that venous blood confined within a bladder, undergoes a ſimilar change, when the bladder is immerſed in oxygenous gas. It has been alſo found, that when arterial blood out of the body is expoſed to the action of irreſpirable gaſes, it loſes its bright colour, and aſſumes the purple hue of venous blood.

236 Increaſe of temperature.

It is fully aſcertained, that the heat of the body is chiefly kept up by reſpiration, See CHEMISTRY, N° 2545.

237 Theory of reſpiration.

Let us now conſider the moſt probable theories of reſpiration, chiefly as they are applicable to the human ſyſtem. Without ſtaying to notice the older hypotheſes that have been advanced to explain this function, we ſhall only ſtate the preſent moſt received doctrine, and mention the objections that have been lately made to it.

238 Theory of Allen and Boſtock.

This doctrine is ſtated in the following manner by Dr Boſtock, one of its moſt ſtrenuous defenders. "The blood ariſes at the right ſide of the heart, in a venalized ſtate, loaded with a quantity of the oxyde of carbone; as it paſſes through the pulmonary veſſels, it becomes ſubjected to the action of the air contained in the bronchial cells; a portion of the oxygen is removed from the air, part of which, forming an intimate union with the oxyde of carbone, is expelled in the form of carbonic acid gas, while the remainder is diſſolved in the blood." It is here neceſſary to remark, that it is not *oxygenous gas*, but *oxygen*, which is ſuppoſed to be mixed with the blood. The caloric thus ſet at liberty is employed, part of it in maintaining the temperature of the lungs, which would otherwiſe be cooled by the admiſſion of the external air; part of it in carrying off the aqueous vapour, and another portion in converting the carbonic acid into carbonic acid gas; but the greateſt part of it is united, in the form of ſpecific heat, to the arterial blood, which, by becoming arterialized, has its capacity for heat increaſed. The arterial blood is poured into the left cavity of the heart, and propelled through the arteries into the extreme parts of the body. The oxygen which was diſſolved in the whole maſs of blood, during the circulation, gradually unites itſelf more intimately to a portion of the carbone in it, which it converts into the oxide of carbone, and thus the blood acquires the venous ſtate. By this change, its capacity for caloric is diminiſhed; the ſpecific heat which it obtained in the lungs, is given out in the capillary veſſels, to keep up the temperature of the body, and the blood returns to the right ſide of the heart completely venalized. This hypotheſis is nearly ſimilar to the one which was propoſed by M. M. La Grange and Haſſenfratz; it received ſome modifications from Mr Allen of Edinburgh, and was delivered by him nearly in the form which I have ſtated above, in his admirable courſe of phyſiological lectures. It was, I believe, firſt publiſhed in my Eſſay on Reſpiration *."

* *Edin. Med. Jour.* vol. iv. p. 160.

This doctrine, if ſufficiently eſtabliſhed, would explain the manner in which the blood becomes arterialized in the courſe of the circulation. It would alſo ſhew how, under particular circumſtances, the arterial blood may be venalized without leaving the arteries, and the venous blood arterialized without leaving the veins. It accounts for the gradual evolution of caloric in the capillary veſſels, during the courſe of the circulation, by the union which takes place between the oxygen and the carbone; whereas in the other hypotheſis, (ſee N° 241.;) this union is entirely completed in the lungs. It would allow a conſiderable time in which this union might be accompliſhed, and would likewiſe ſuppoſe the conſtituent parts to remain in perfect contact for an indefinite period. This hypotheſis would alſo explain how the oxygen is diſpoſed of, which is ſuppoſed not to be concerned in the formation of carbonic acid, and would likewiſe poſſeſs the advantage of ſuppoſing the exiſtence of a ſurplus quantity of oxygen, which being carried along the circulation, might be expended in a variety of uſeful purpoſes in the different parts of the animal economy. It would ſhew how the ſupply of matter which is poured into the blood by the abſorbents, is gradually incorporated with the maſs; and after the ſeparation of that portion, which is neceſſary for repairing the waſte of the different organs, the remainder is united to oxygen, and keeps up the temperature of the body; and, having afterwards no farther uſeful purpoſe to ſerve, it is diſcharged by the lungs †.

† *Ib.* p. 167.

239 Objections.

Several objections, however, may be made to this theory. It is not proved that there is in natural reſpiration any abſorption of oxygen by the blood; for though much of the oxygenous portion of the atmoſphere is loſt, the quantity of carbonic acid generated is ſufficient to account for it. Mr Ellis has lately made very ſtrong objections to this ſuppoſed abſorption of oxygen, drawn chiefly from the anatomical ſtructure of the blood veſſels, and of the bronchial cells. He contends that the coats of the former, and the membranes bounding the latter, can ſcarcely admit the paſſage of air through them, much leſs that of the ſolid baſis of oxygenous gas, which baſis Dr Boſtock ſuppoſes to be the principle abſorbed. It is ſtill more improbable, according to Mr Ellis, that two ſolid baſes, namely thoſe of oxygenous gas, and of oxide of carbone, ſhould be at the ſame time paſſing through

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through theſe reſiſting membranes; a ſuppoſition that is neceſſary in the hypotheſis juſt ſtated. Again, ſuppoſing that this abſorption of oxygen ſhould take place, from the affinity of the blood for this principle, it is not eaſy to conceive why this affinity ſhould ſo ſoon ceaſe, and why the blood ſhould again part with the oxygen, to the baſe of carbonic oxide ‡. Theſe objections are certainly very forcible; let us ſee how they have been anſwered.

‡ *Ellis's Inquiry*, p. 117.—123.

240 anſwered.

Dr Boſtock, in an ingenious reply to Mr Ellis's objections, in invalidation of the firſt objection, quotes the well-known experiment of Dr Prieſtley, mentioned in N° 235. that venous blood becomes changed when expoſed to oxygenous gas, even though a bladder be interpoſed between them; and in controverting of the reſt, he ſeems chiefly to rely on the ſuppoſition that a greater quantity of oxygen is conſumed than is taken up in the formation of the carbonic acid. He alſo does not conſider it as *neceſſary* to ſuppoſe that either the oxygenous gas, or the oxygen itſelf, ſhould enter the blood-veſſels, and ſhould afterwards be expelled from them; but only that a *part of the oxygen* ſhould be *attracted* by the blood, and after entering into a variety of new combinations, ſhould be diſcharged as a conſtituent of ſome of theſe new compounds. Without inquiring in what way the action between the blood and oxygen takes place; whether it be in conſequence of the mechanical ſtructure of the membranes, which permits the oxygen to paſs through their pores, or whether it be owing to the affinity of the blood for oxygen, which cauſes it as it were to become ſaturated with this ſubſtance before it tranſmits it; it appears to him ſufficient to ſtate, that oxygen and blood can act on each other, through a membrane which is very much thicker, and probably much denſer, than that which ſeparates the blood in the lungs from the air in the bronchial cells *.

* *Edin. Med. Jour.* vol. iv. p. 161. *et ſeq.*

241 Mr Ellis's opinion.

From a conſideration of the principal experiments on reſpiration that have been made by the ableſt chemical phyſiologiſts, and a compariſon of theſe with what he has himſelf made, Mr Ellis contends that no part of the air enters into the blood, but all the oxygen which diſappears is to be found in the carbonic acid produced; and that this carbonic acid is formed by the union of carbone emitted by the exhalant veſſels of the lungs, uniting with part of the oxygenous portion of the inſpired air †.

† *Edin. Med. Jour.* vol. iv. p. 327.

242 Objections

To this opinion Dr Boſtock, in the paper already referred to, makes the following objections; that this opinion does not explain how the regular ſupply of carbone is, at each ſucceſſive circulation, brought to the lungs in a ſtate proper to be diſcharged; and that it does not explain in what way the oxygen is employed, which is conſumed in reſpiration ‡.

‡ *Edin. Jour.* vol. iv. p. 163.

243 anſwered.

To the firſt of theſe objections (which, if it be proved that the whole of the oxygen is taken up in forming carbonic acid, is the only objection that can properly lie againſt his opinion), Mr Ellis replies, that the ſupply of carbone is derived from the digeſtive organs; but he does not conceive, as Dr Boſtock ſeems to imagine, that this is no ſooner received into the blood than excreted, or that the firſt operation which takes place in the ſanguiferous ſyſtem after it has received the ſubſtance which is to afford nutriment to the body, is to diſcharge the greateſt part of it. He regards carbone as a conſtituent part of the animal fluids, and he has endeavoured to ſhew, that it is emitted by the exhalants of the ſkin and inteſtines, as well as by thoſe of the lungs, producing in all caſes ſimilar changes on the air. Digeſtion he holds to be in no other way the ſource of the carbone in theſe fluids, than as it is the ſource of all the other principles which they contain. We know that all the phenomena of reſpiration are often exhibited for long periods where no digeſtive proceſs is carried on; but the functions of life muſt ſooner or later come to an end, if the various means of exhauſtion be not recruited by ſupplies through the digeſtive organs. It is only in this diſtant view that he conſiders digeſtion as the ſource of carbone; its immediate ſources are the exhalant functions of the body, which will afford carbone as long as they are ſupported by the motion of the blood, and will no longer yield it when the motion of the blood has ceaſed. But whether the exhalant functions continue or ceaſe, he conſiders that carbone exiſts abundantly, if not equally, in the ſerum and craſſamentum, in arterial and venal blood *.

* *Edin. Jour.* vol. iv. p. 327.

244 Theory of reſpiration ſtill incomplete.

On the whole, though the final cauſes of reſpiration, or the uſes to which it is ſubſervient in the animal economy, are now pretty well underſtood, we muſt acknowledge that the mode in which theſe beneficial effects are produced, has not yet been ſatiſfactorily explained.

245 Uſes of reſpiration.

The principal uſes of reſpiration appear to be, 1. To bring about ſome beneficial change in the fluids of the body, and through them on the ſolids; 2. To preſerve the equable temperature of the body; and 3. In all thoſe animals that breathe by lungs to produce thoſe ſounds which ariſe from what we call *voice*.

246 Animal heat.

That animal heat is kept up chiefly by reſpiration, requires we think, no particular proof. It is well known, that thoſe animals which conſume moſt air during reſpiration, have the higheſt temperature. Birds in particular have the moſt extenſive breathing organs, and the temperature of theſe animals is higher than that of any other claſs. The reſpiration of reptiles, fiſhes, and moſt of the lower claſſes, is ſlow and languid, and the temperature of theſe animals is proportionally low. The heat of each ſpecies is, however, pretty uniform under ordinary circumſtances. That of the human body is generally about 98° of Fahrenheit. This however depends on the circumſtances in which it is placed. When much chilled by the action of cold, the temperature of the human body falls a degree or two below the ordinary height; and under the influence of violent fever, it riſes ſeveral degrees above it. The temperature is generally higheſt in children; and inſtances are recorded of theſe having ſurvived, while their mothers, to whoſe breaſts they clung, have periſhed from the ſeverity of cold.

247 Preſervation of equable temperature.

One of the moſt intereſting facts relating to the ſubject of animal heat, is the capacity of preſerving the equable temperature of their bodies, poſſeſſed by moſt animals. Man himſelf can live with little inconvenience in the frozen regions of Spitzbergen, and under the equatorial heats of Africa. He can even ſupport a greater degree of heat than is perhaps ever known to take place from the rays of the ſun, as is proved by the experiment of Drs Blagden and Fordyce in heated rooms; theſe gentlemen having remained for 15 minutes together in a heat exceeding 130°. The heat ſupported by ſome of the inferior animals is ſtill more extraordinary. A dog has been known to live for a conſiderable time in air heated to 260°, and ſtill the heat of his body was not raiſed more than 2° above its natural ſtandard. A frog has lived for more than 25 minutes when laid on flannel,

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nel, heated from 95° to 106°. Fishes live very well at 72°; and Lucas, in his history of mineral waters, speaks of carp that were living in a hot bath, whose temperature was at least equal to that of the human body.

How this equable temperature is preserved, cannot be completely explained. We know that the heat of the human body is commonly moderated by perspiration; but in some cases, as in that of Dr Fordyce alluded to above, where the heated atmosphere was filled with watery vapour, this could have little effect. We can ascribe it only to the action of the living principle.

248 Voice.

It was long ago observed by Aristotle, that those animals only who possess lungs, have a true voice, and this opinion is confirmed by the experience of modern naturalists. We find, that only mammalia, cetacea, birds, reptiles and serpents, can utter vocal sounds. Several tribes below these do indeed emit certain sounds, especially insects; but these are owing to vibrations of the air in consequence of the agitation of their external organs. It is only in mammalia and birds that the voice becomes an interesting object of enquiry; for that of the cetacea is little more than blowing and grunting, and that of the other two classes is either hissing or croaking.

249 Amazing variety of the human voice.

Nothing can exceed, in variety and execution, the human voice; as will readily be allowed, if we consider the complicated structure of the human vocal organs, and the almost infinite variety of changes of which they are susceptible. Dr Barclay has calculated these with great accuracy, proceeding on the principle, that where a number of moveable parts constitutes an organ destined to some particular function, and where this function is varied and modified by every change in the relative situation of the moveable parts, the number of changes produceable on the organ must at least equal the number of muscles employed, together with all the combinations into which they can enter. Now, the muscles proper to the five cartilages of the larynx, are at least seven pairs; and fourteen muscles that can act separately or in pairs, in combination with the whole, or with any two or more of the rest, are capable of producing 16,383 different movements; not reckoning as changes the various degrees of force and velocity, nor the infinitely varied order of succession by which they may occasionally be brought into action. The number appears almost incredible; but to lessen the surprise, it must be recollected that we speak not here of the powers possessed by any individual, which will depend on habits and circumstances, but of the powers of the vocal organs, considered in the abstract, free from all the influence of custom, equally indifferent, and equally disposed to act in any order of succession, in any combination, and with any degree of force and velocity of which their original powers were susceptible.

If the powers we have mentioned appear astonishing, and able to account for many thousands of these varieties observed among the voices of the human species, we have further to add, that the muscles alluded to are only the proper muscles of the *larynx*, or the muscles restricted in their attachments to its five cartilages. These are but a few of the muscles of voice. In speaking we use a great many more. Fifteen pairs of different muscles, attached to the cartilages, or *os hyoides*, and acting as agents, antagonists, or directors, are constantly employed in preserving the cartilages of the larynx steady, in regulating the place of their situation, or moving them as occasion requires, upwards and downwards, backwards and forwards, and in every way, directly and obliquely, according to the course of the muscular fibres, or in the diagonal between different forces. These muscles, independent of the former, are susceptible of 1,073,741,823 different combinations; and co-operating with the seven pairs of the larynx, of 17,592,186,044,415, exclusive of the changes which must arise from the different degrees of force and velocity, and the infinitely varied order of succession in which they may be brought into action.

But these are not all that co-operate with the larynx, either in forming or changing the voice; the diaphragm, the abdominal muscles, the intercostals, and all that directly or indirectly act on the air, or on the parts to which the chondral and hyoidal muscles are attached, contribute their share. The *os hyoides* could not be raised unless the inferior jaw-bone were previously fixed by the *temporals*, *masseters*, and internal *pterygoids*; and a similar assistance is likewise furnished by several other auxiliary muscles that fix the head, *sternum*, and *scapula*; to these we must add some pairs belonging to the *pharynx* and *isthmus faucium*, and some also belonging to the tongue, which, combining with others, give to that organ an inconceivable variety of movement; and so quickly, that, in rapid utterance, they change its state 3000 times in a minute. Thus Haller could articulate 1500 letters in a minute, which required 1500 contractions, and as many relaxations of the lingual muscles †.

† Barclay's Anat. Nomen. p. 70.

250 Mechanism of voice and speech.

The principal organ of voice is the larynx, which is proved by the circumstance that, when this is injured, the voice is either lost, or rendered very indistinct. In ordinary respiration the chink of the glottis seems to be in a relaxed state, and when this chink is contracted, voice is produced, and the sound of the voice is more or less shrill, according as the *glottis* is more or less contracted. By this contraction of the glottis alone we can produce only inarticulate sounds, varied indeed almost infinitely with respect to intensity and tone, by the action of the muscles. The production of speech requires the action of the tongue, the lips, the palate, and the teeth; and the articulations are most complete, when all these parts are most perfect in their structure, and in the most healthy condition. Too great length or shortness of the tongue, swelling of this organ in consequence of inflammation, &c. imperfection of the palate, loss of the teeth, swelling of the lips, all serve to render speech imperfect and inarticulate. The strength of the voice depends on the quantity of air expired, and on the contraction of the glottis; and consequently those animals who have the most capacious and most dilatable lungs, together with an ample cartilaginous and elastic larynx, will, other things being equal, have the strongest voice.

251 Ventriloquism.

Among the various effects of the human voice, there is none more calculated to produce surprise in the hearers, than that extraordinary talent which some men possess of deceiving their hearers into a belief, that the sounds which they utter do not proceed from the real speaker, but from situations at a distance. This talent has been termed *ventriloquism*, from an idea that the voice of the speaker proceeded not from the mouth, but from the belly. The most remarkable instance of this rare talent of which we have heard, is that of M. Fitz-James, who was formerly at Paris, and exhibited in London in the year 1803. Mr Nicholson has given an amusing

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amufing account of the performance of this ventriloquift, and we fhall prefent part of it to our readers.

After fome remarks on the nature of ventriloquifm, which we fhall notice prefently, and on the difficulty of afcertaining the direction of the found, Mr Nicholfon thus proceeds:—" We fhould fcarcely be difpofed to afcribe any definite direction to it; and confequently are readily led to fuppofe it to come from the place beft adapted to what was faid. So that when he went to the door, and afked in French (in which the whole performance was carried on), ' are you there?' to a perfon fuppofed to be in the paffage, the anfwer in the unufual voice was immediately afcribed by the audience to a perfon actually in the paffage; and upon fhutting the door and withdrawing from it, when he turned round, directing his voice to the door, and faid, ' ftay there till I call you,' the anfwer which was lower, and well adapted to the fuppofed diftance, and obftacle interpofed, appeared ftill more ftrikingly to be out of the room. He then looked up to the cieling and called out in his own voice, ' what are you doing above?' ' do you intend to come down?' to which an immediate anfwer was given, which feemed to be in the room above, ' I am coming down directly.' The fame deception was practifed on the fuppofition of a perfon being under the floor, who anfwered in the unufual, but a very different voice from the other, that he was down in the cellar putting away fome wine. An excellent deception of the watchman crying the hour in the ftreet, and approaching nearer the houfe, till he came oppofite the window, was practifed. Our attention was directed to the ftreet by the marked attention which Fitz-James himfelf appeared to pay to the found. He threw up the fafh and afked the hour, which was immediately anfwered in the fame tone, but clearer and louder; but on his fhutting the window down again, the watchman proceeded lefs audibly, and all at once the voice became very faint, and Fitz-James in his natural voice faid, ' he has turned the corner.' In all thefe inftances as well as others which were exhibited to the very great entertainment and furprife of the audience, the acute obferver will perceive that the direction of the found was imaginary, and arofe entirely from the well-ftudied and fkilful combinations of the performer. Other fcenes which were to follow required the imagination to be too completely mifled to admit of the actor being feen. He went behind a folding fcreen in one corner of the room, when he counterfeited the knocking at a door. One perfon called from within, and was anfwered by a different perfon from without, who was admitted, and we found from the converfation of the parties, that the latter was in pain, and defirous of having a tooth extracted. The dialogue, and all the particulars of the operation that followed, would require a long difcourfe if I were to attempt to defcribe them to the reader. The imitation of the natural and modulated voice of the operator, encouraging, foothing, and talking with the patient; the confufion, terror, and apprehenfion of the fufferer; the inarticulate noifes produced by the chairs and apparatus, upon the whole, conftituted a mafs of found which produced a ftrange but comic effect. Some obfervers would not have hefitated to affert, that they heard more than one voice at a time; and though this certainly could not be the cafe, and it did not appear fo to me, yet the tranfitions were fo inftantaneous, without the leaft paufe between them, that the notion might very eafily be generated. The removal of the fcreen fatisfied the audience that one performer had effected the whole.

" His principal performance, however, confifted in the debates at the meeting of *Nauterre*, in which there were twenty different fpeakers, and certainly the number of different voices was very great. Much entertainment was afforded by the fubject, which was taken from the late times of anarchy and convulfion in France; when the loweft, the moft ignorant part of fociety, was called upon to decide the fate of a whole people by the energies of folly and brûte violence. The fame remark may be applied to this debate, as to the other fcene refpecting tooth-drawing; namely, that the quick and fudden tranfitions, and the great differences in the voices, gave the audience various notions, as well with regard to the number of fpeakers, as to their pofitions and the direction of their voices †."

† *Philof. Jour.* 8vo. vol. iv. p. 203.

252 How explained.

Various explanations of this peculiar modification of voice have been given. From the report of Fitz-James himfelf, it appeared to Mr Nicholfon, that by long practice he had acquired the faculty of fpeaking during the infpiration of the breath, with nearly the fame articulation, though not fo loud, nor fo varioufly modulated, as the ordinary voice, formed by expiration of the air. M. Richerand, who heard Fitz-James at Paris, gives a different account of the matter. He fays that every time the ventriloquift exerted this unufual peculiarity, he fuffered diftention in the epigaftric region; that fometimes he perceived the wind rolling even lower, and that he could not long continue the exertion without fatigue. Richerand believes that the whole mechanifm of this art confifts in a flow, gradual expiration, drawn in fuch a way, that the artift either makes ufe of the influence exerted by volition over the mufcles of the parietes of the thorax, or that he keeps the epiglottis down by the bafe of the tongue, the apex of which is not carried beyond the dental arches.

He always made a ftrong infpiration juft before this long expiration, and thus conveyed into the lungs a confiderable mafs of air, the exit of which he afterwards managed with fuch addrefs. Therefore repletion of the ftomach greatly incommoded the talent of M. Fitz-James, by preventing the diaphragm from defcending fufficiently to admit of a dilatation of the thorax, in proportion to the quantity of air that the lungs fhould receive. By accelerating or retarding the exit of the air, he can imitate different voices, and induce his auditors to a belief, that the interlocutors of a dialogue kept up by himfelf alone, are placed at different diftances ‡.

‡ *Richerand's Phyfiol. by Kerrifon*, p. 370.

Mr Gough in an ingenious paper, containing an inveftigation of the method whereby men judge, by the ear, of the pofition of fonorous bodies, relative to their own perfons, explains the phenomena of *ventriloquifm*, on the principles of reverberated found, and confiders it as confifting in the talent of making the voice iffue only from the mouth; whereas he thinks that in ordinary cafes the different vibrations which are excited by the joint functions of the feveral vocal organs in action, pafs along the bones and cartilages from the parts in motion, to the external teguments of the head, face, neck, and cheft, from which a fucceffion of fimilar vibrations is imparted to the contiguous air, thereby converting the upper half of the fpeaker's body into an extenfive feat of found. He thinks that the founds proceeding from the mouth

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mouth of a ventriloquist are uttered in such a direction that the hearers may receive the impression of some echo with much more force than they can receive the original sounds *. It may be doubted whether such echoes can take place in an ordinary room filled with a large assembly; and on the whole we are inclined to consider this phenomenon as being effected partly by the gradual emission and a skilful management of a large quantity of air taken in by a full inspiration, and partly by the influence which the performer is capable of exerting over the imagination of his hearers.

* *Manchester Memoirs*, vol. v. part ii. p. 622.

253 Voice of brutes.

Several of the mammalia have a characteristic voice, which is formed by particular organs. These are in some animals tense membranes; in others peculiar cavities opening into the larynx, and sometimes appearing like continuations of the laryngeal ventricles. Thus the neighing of the horse is effected by a delicate, and nearly falciform, membrane, which is attached by its middle to the thyroid cartilage, and has its extremities running along the outer margins of the opening of the glottis. The braying of the ass is produced by means of a similar membrane, under which there is an excavation in the thyroid cartilage. In this animal there are also two large membranous sacs opening into the larynx. The purring of the cat seems to be owing to two delicate membranes that lie below the ligaments of the glottis. Some of the monkey tribe, especially the *simia seniculus* and beelzebul, have the middle and fore part of the *os hyoides* formed into a spherical bony cavity, by which these animals are enabled to produce those horrible and penetrating tones, which can be heard at vast distances, and have gained them the name of howling apes †. See MAMMALIA, N° 33.

† Blumenbach's *Comp. Anat.* chap. xv.

254 Voice of birds.

The simplest vocal organ seems to be that of birds. These animals have, on the sides of the windpipe next the lungs, and at the opening of the bronchiæ, two membranous folds which partly close the pulmonary aperture of the windpipe, and the aperture next the head is susceptible of great contraction and dilatation. In short, the vocal organ of birds may be considered as one of the most perfect wind instruments, very much resembling, both in its structure and effect, a clarinet or hautboy, the opening next the lungs being similar to the reed of these instruments. For some remarks on the song of birds, see ORNITHOLOGY, N° 42; and for farther observations on the voice, see ANATOMY, Part I. N° 122.

255 Relations of respiration with other functions.

In tracing the relations of respiration with the preceding functions, we must deviate a little from our usual order, and begin with those between respiration and *circulation*, as it seems to be through the medium of the circulating system that respiration principally acts on the other functions. The relations between respiration and circulation are the most immediate and the most obvious.

256 With circulation.

When the *breathing* is most free and rapid, the circulation is most vigorous and active; while in laborious or interrupted respiration, the action of the heart and arteries becomes slow, feeble, irregular; and where the lungs are deprived of oxygenous gas, the *arteries* gradually cease to pulsate, and soon after the motion of the *heart* ceases. If the stimulus of oxygen be not too long withheld, so that the lungs can again be excited to action, first the heart, and then the arteries, gradually renew the exercise of their functions, and the circulation proceeds as before. On the application of these principles depends the recovery of those apparently dead from *asphyxia* (suffocation, drowning, &c.). When the circulation becomes languid from indolence, from depressing passions, or the want of accustomed stimuli, we feel about the breast a peculiar sensation, which physicians call *anxiety*, and which is relieved by a deep inspiration; by sighing, yawning, &c. Violent exertions of the respiratory organs, such as laughing, coughing, singing, talking unusually long or loudly, quicken the circulation, sometimes to an alarming degree, so as to occasion hæmorrhage in such as are predisposed to that affection. Breathing in an atmosphere that is much rarefied, as on the top of a high mountain, has often the effect of producing plethora and hæmorrhage; though this, perhaps, is imputable rather to a want of the ordinary pressure on the surface of the body.

When the circulation through the lungs is impeded or obstructed, a determination of blood takes place to other parts, especially to the head. The effects produced on the brain and other organs of sensation, by the breathing of impure air, are dreadful. When the same quantity of air is repeatedly respired, there is experienced, first, great anxiety about the breast, and this soon becomes intolerable; the face swells, becomes livid, or even black, and feels excessively hot; sparks of fire seem to dance before the eyes; the sight becomes depraved; giddiness, ringing in the ears, and confusion of thought succeed; and if fresh air be not soon supplied, the subject of the experiment loses both sensation and motion, and falls into a state resembling apoplexy ‡. When rarefied air is breathed, the nervous system experiences a kind of excitement; agreeable sensations are produced, with a disposition to mirth and cheerfulness; but if the person continue for some time in such a situation, an unusual languor, heaviness, and disposition to sleep, come on †. We need not here describe the pleasurable sensations excited by the respiration of nitrous oxide, as these have been already related under CHEMISTRY, N° 366. The exhilarating effects which a pure and serene atmosphere produce on the general system, and the uneasy sensations experienced under a thick and clouded sky, are partly referable to this head. The nervous system also acts on the organs of respiration. In some affections of the brain, respiration is much quickened, while in others, especially the comatose affections, it is slow, laborious, and often attended with that peculiar noise called *stertor*. It is well known what effect anxiety, eagerness, hope, or desire, have on the respiration. According as one or other of these passions is predominant, the breathing becomes hurried, irregular, or suspended.

257 With sensation.

‡ Kite's *Essay on Apparent Death*, p. 25.

† Saussure *Voyage dans les Alpes*, p. 559.

258 With motion;

An evident relation takes place between respiration and motion. The breathing is quickened by exercise; and when there is a considerable debility of the muscular system, the slightest exertion produces hurried respiration, panting, &c. In those animals that possess the greatest powers of motion, respiration is most free, and the air most extensively diffused over the body. In birds, not only the lungs are very extensive, but the air is conveyed into the bones of the skull, and into the hollows of the larger cylindrical bones; and in insects which have the most rapid motions, the air penetrates to every part of the body. Motion, as well as sensation, becomes unusually free and vigorous in rarefied air, and during the respiration of nitrous oxide; while in cases of

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of impeded or obstructed respiration, the action of the muscles is languid and feeble. Indeed, if we may implicitly rely on the experiments that have been made on the respiration of de-oxygenated gases, the muscular fibres are among the first organs that are injured. We are told that by the admission of black blood, or blood that has not undergone the necessary changes by healthy respiration, the muscles lose their power of contraction, and even their irritability.

259 With digestion. The organs and function of respiration sympathise with those of digestion. When the former function is most free, the latter is generally most healthy; the respiration of pure or rarefied air, or of the nitrous oxide, is attended with an increase of appetite, and of the digestive powers, as was experienced by M. Saussure while wandering among the Alps, and by Davy while respiring the *gas of Paradise*. Again, when digestion is impaired, or when the stomach is overloaded, the breathing is rendered difficult, laborious, or irregular, and in many cases of affection of the stomach, cough is a very common symptom. These effects produced on the respiratory organs in consequence of impaired digestion, are ascribable chiefly to the pressure on the diaphragm by the distended stomach.

Many other relations might be pointed out between respiration and the other functions of the animal economy, but our limits do not permit us to enlarge further on the subject *.

For an account of the morbid affections of respiration, such as *sneezing*, *hiccup*, *coughing*, *anxiety*, *dyspnœa*, or *difficulty of breathing*, see the article MEDICINE.

* See *Bichat Recherches Physiol. sur la Vie et la Mort.*

CHAP. IX. *Of Nutrition and Assimilation.*

260 Nature of nutrition. THE function by which the nutritious particles received by a living being are assimilated to the nature of that being, or become part of its substance, is properly called *nutrition*. This is the completion of the process which, in most animals, is the combined result of several other operations. Thus, in the superior animals, from man to the mollusca, the whole process of nutrition consists of *digestion*, *absorption*, *circulation*, and *respiration*; by the two last of which the nourishment received is changed into perfect blood, and fitted for the support and renewal of the several parts of the system. From the account of the constituent parts of the blood given under CHEMISTRY, N° 2660, it will appear, that this fluid contains within itself the principles of which every part of the body is composed. Thus it contains *fibrine*, which is the chief principle of the muscular parts; *phosphate of lime*, which forms the basis of the bones; *albumen* and *gelatine*, the chief constituents of cartilages, ligaments and tendons, &c. These principles are conveyed by the arterial blood, during its circulation, to those parts of the system where they are required, for renewing waste, or supplying deficiencies, and thus they are assimilated to the nature of the body.

261 Each assimilating organ produces peculiar changes. The power of assimilation, so remarkable in living bodies, is not the same in every assimilating organ; but each has the property of converting the materials it receives (provided they be susceptible of this conversion) into a peculiar substance. Thus, the stomach always converts the food into *chyme*; the intestines change it into *chyle*; but if chyle, or what is very similar to it, fresh milk, be received into the stomach, this organ exerts on it the usual change, and does not pass it forward into the intestines unaltered, though we know by experiment, that fresh milk is capable of being taken up unchanged by the absorbents of the bowels *. Again, blood is always perfected within the circulating vessels; and if chyle or fresh milk be injected into the arteries, it produces dangerous effects, while the fresh blood of another living animal may be transfused into these vessels without injury. In like manner, if a piece of fresh muscular flesh be cut from a living animal, and applied to the muscles of another living animal, also newly divided, the two parts unite, and are immediately assimilated; and even fresh bone may, in the same manner be ingrafted on the living bones of the same, or of a different species of animal †; while substances that are foreign to the nature of the animal body, when introduced into the blood-vessels, prove fatal, and when inserted into a wounded muscular or bony part, prevent the wound from healing.

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* *Fordyce on Digestion*, p. 189.

† *Phil. Mag.* vi. 308.

262 Assimilation a chemical process. These circumstances show that assimilation is a chemical process, though modified and regulated by the action of the living principle. The chemical nature of assimilation is most distinctly proved by the well-known experiment of colouring the bones of an animal, by feeding it on madder. The particles of the madder, which we know to have a strong affinity for phosphate of lime, are carried unchanged from the stomach into the blood-vessels, and are thence conveyed, probably in combination with the phosphate of lime there contained, into the substance of the bones, where they are deposited, and remain for a considerable time.

263 Nutrition not performed by nerves. We have considered nutrition as performed by the circulating vessels. It has been supposed that the nerves are the organs of nutrition; but this strange hypothesis is completely overturned by an experiment of the second Monro, which proves that the limb of a frog may be preserved alive and nourished by the blood-vessels, after its communication with the brain has been cut off by dividing the nerves.

264 Nutrition in insects and zoophytes. In insects and zoophytes, where there are no circulating vessels, nutrition must be a very simple operation. According to Cuvier, it is performed by *imbibition*; the pores of the animal's body receiving immediately the nutritious fluids on which it feeds.

265 Assimilating power limited. In plants and animals, the assimilating power has always certain limits prescribed to it; its influence is very generally confined to the sort of food congenial to the species, and its strength is varied according to circumstances, as the age, the habits, and the state of health. Those which are young assimilate faster than those which are old; and one species, which may partly be owing to the nature of their food, will assimilate much faster than another. Certain worms that feed on animal and vegetable substances will, in twenty-four hours after their escape from the egg, become not only double their former size, but will weigh, according to Redi, from 155 to 210 times more than before. Most oils are of very difficult assimilation; and those which are *volatile* will often resist the long-continued and the varied action of the living organs; will mingle with the parts, and, undecomposed, communicate their flavour.

Other circumstances respecting nutrition have been noticed

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noticed in the first part of ANATOMY, N° 130; and the chemical doctrine of assimilation is more fully considered under CHEMISTRY, N° 2576—2571.

CHAP. X. *Of Secretion.*

266 Secretion. THAT function by which any organ, or set of organs, separates from the general mass of blood certain principles intended to perform some important office in the animal economy, is called *secretion*; and the substances so separated, are called *secretions*.

267 Organs. The secretory organs in the more perfect animals are very numerous, and some of them very complex. The most simple of them seem to be the *cellular texture*, and the *mucous membranes*. The next in simplicity are the *conglobate glands*, and perhaps the *spleen*, while the more complex organs are the *liver*, the *testicles*, the *atrabiliary capsules*, &c. An account of all these organs, as they occur in the human body, has been given in the first part of the article ANATOMY; and the corresponding organs of the inferior animals, with others not found in man, are described by writers on comparative anatomy, especially Cuvier and Blumenbach.

268 Kinds of secretion. Secretion appears to be of three kinds: 1. *Transudation*, in which the secreted matters merely ooze through the pores of the secreting organ. This takes place in the lowest classes of animals, as in zoophytes, insects, and some worms, but rarely in the human subject. 2. *Exhalation*, in which the secreted fluids are poured out into cavities by certain branches of the arteries with open mouths, called *exhalants*. This appears to take place in many organs of the most perfect animals, especially from the mucous membranes, the synovial glands, &c. 3. *Secretion*, properly so called, in which the blood passes through glandular bodies, where a part of it is decomposed, and carried out in another form by particular tubes called *excretory ducts*. This is the case with most of the secreting organs, as the salivary glands, the lachrymal glands, the liver, the pancreas, the testicles, and a few others.

269 Secreted matters. The secreted fluids are chiefly the following: *lymph*, *serum*, *tears*, *mucus*, *saliva*, *pancreatic juice*, *gastric juice*, *enteric juice*, *bile*, *semen*, *synovia*, *fat*, *marrow*, *cerumen* or *ear-wax*, and in the female, *milk*. The other matters secreted, which may rather be termed solid than fluid, are *albumen*, *gelatine*, *fibrine*, and *phosphate of lime*. On the nature and properties of all these substances, see the article CHEMISTRY, Chap. xix. sect. 3.

With respect to the secretions in general, we may remark, that they are considerably influenced by age, sex, various affections of the mind, and various bodily diseases. They are formed by organs which are sometimes capable of supplying the deficiencies of each other; they are subjected to the influence of the atmosphere, and to the temperaments of the body; they are sometimes mixed together, and by this combination their nature is changed.

270 General modifications of secretion.

We shall now briefly examine the action of three of the secreting organs, viz. the *cellular membrane*, the *liver*, and the *spleen*.

271 Action of the cellular membrane. From the extensive distribution of the cellular membrane it is reasonable to conclude, that it is intended to perform several important offices in the animal economy. One of its most obvious uses is to form a general connecting medium between every part of the structure, while it at the same time separates and distinguishes every organ. From its elasticity, and the lubricating fluid which it holds within its cells, it facilitates motion, and thus assists the action of all the muscular parts and organs. That it is susceptible of great dilatation is proved by the phenomena of anasarcous dropsy; and the gradual evacuation of the water when anasarcous limbs are punctured, as well as the passage of extraneous bodies below the skin from one part to another, seem to show that it possesses considerable contractile powers. It is chiefly, however, as a *secreting* organ that we are here to consider the *cellular membrane*; and in this way its function is of the utmost importance. The *fatty matter*, that is so copious in most of the superior animals, is contained within particular cells or *bags* of the cellular membrane, and is found in greatest quantities below the skin, especially on the *sternal* part of the belly, and about the kidneys. In some animals, as the *hog*, the *seal*, the *walrus* and the *cetaceous* tribes, it forms a layer several inches in thickness, and in all the water animals above mentioned it is nearly fluid. To these animals it not only serves the purposes of a warm covering by the slowness with which it conducts heat; but, by diminishing their specific gravity, renders their motions on the surface of the water much more easy and expeditious. One of the most important uses of the fat seems to be to supply nourishment to the body, when the ordinary channel is obstructed, or the system rendered incapable, from torpor or disease, of receiving food. When fat persons are attacked by fever, or similar acute diseases, they become emaciated, sometimes to so great a degree as to appear a mere skeleton; and those animals who sleep during winter, though very fat when they retire to their dormitories, are extremely lank and lean when they quit these on the return of spring. In all these cases the fat alone is absorbed, and supplies the waste that takes place in the body, and would otherwise prove fatal.

On the actions of the cellular membrane, see Bichat, *Anatomie Generale*, tom. i.

Some physiologists have supposed that the bile secreted by the liver is not formed entirely from the blood of the *vena portarum*, but partly from the hepatic artery. 272 Action of the liver. Dr Saunders, who has examined the arguments in favour of this supposition, decides against it, and considers the usual opinion of the bile being solely secreted from the blood of the *vena portarum*, as quite satisfactory. It has also been supposed, that the whole of the bile is not secreted by the liver, but that the gall bladder has a share in this office, and is not merely a reservoir, like the urinary bladder. This supposition is highly improbable, although we think there can be little doubt that the bile undergoes, within the gall bladder, some peculiar changes, which render it better fitted for the functions it has to perform. We know that the gall bladder is very muscular, and that there is an appearance of follicles within it. It is therefore probable that some matter is secreted from its internal surface, which produces a necessary change in the bile.

The principal use of the bile seems to be to stimulate the intestines, and thus keep up their energy and peristaltic motion, though it is probable that, besides this office, it performs several others of importance in the animal economy, such as assisting in the decomposition of the food, and thus forming chyle; and acting as a general 273 Uses of the bile.

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general ſtimulus to the ſyſtem. That it has this laſt effect is probable from the torpor, inactivity, and dejection that attend hypochondriacal and chlorotic affections, in which this ſecretion is defective. Too great a ſecretion, or rather excretion of bile, is attended with violent purging *.

* See *Saunders on the Liver.*

On the nature of the bile, and biliary concretions, ſee CHEMISTRY, N° 2664.

274 Uſes of the ſpleen.

Few ſubjects in phyſiology have given riſe to more diſcuſſion, and few have been conſidered with ſo little ſucceſs, as the uſe of the ſpleen in the animal economy. That an organ ſo large, and ſo well ſupplied with blood, ſhould be intended for ſome important function, is ſcarcely to be doubted; and yet the inſtances of animals that have lived, ſeemingly with little inconvenience, after the ſpleen had been cut out, ſeem to prove that this organ is not of ſuch great importance as it appears to be. The conjectures reſpecting its uſes are various, and ſome of them not a little ludicrous. Some have ſuppoſed that it acted by its weight and preſſure on the ſtomach, and thus promoted digeſtion at one time, and counteracted hunger at another; ſome, that it was intended to dilute and attenuate the blood; others, to deprive that fluid of its ſuperabundant oil; another party, that it contributed to form the red globules of the blood; and ſome of the older phyſiologiſts ſuppoſed that it ſecreted that fluid to which they gave the name of *black bile*. Dumas is of opinion that it is a ſort of ſupplementary organ, both to the liver and the kidneys, ſeparating from the blood part of its ſeroſity, and then delivering it over to the liver in a proper ſtate for the formation of bile; and furniſhing to the kidneys another portion of ſeroſity to form the watery part of the urine *. That at leaſt a part of theſe opinions of Dumas has ſome foundation, will appear from the following ſummary of the late experiments of Mr Everard Home.

275 Opinion of Dumas.

* *Principes de Phyſiol.* tom. iii p. 592.

276 Experiments of Mr Home.

Proſecuting the inquiry reſpecting the ſtate of the ſtomach during digeſtion, which we have formerly alluded to (ſee N° 161), Mr Home found that during digeſtion, the fluids taken into the ſtomach are principally contained in the cardiac portion; and he inferred, from the uniform conſiſtence of the chyme in the pyloric portion, that a great part of the fluids are carried out of the ſtomach without ever reaching the *pylorus*. As he conceived very naturally, that the lymphatics of the ſtomach were inadequate to this office, he conjectured that the fluids might paſs off by the ſpleen. He proved, by a deciſive experiment, that liquors might paſs through the ſtomach without going through the pylorus, and he alſo found at the ſame time, that the ſpleen was turgid, unuſually large, and its external ſurface very irregular; and when cut into, ſmall cells were every where met with, containing a watery fluid, and occupying a conſiderable portion of its ſubſtance. Rudiments of theſe cells had been ſeen before by Malpighi, who conſidered them to be glands, and by Cuvier, who calls them corpuſcles; but the cells in a diſtended ſtate ſeem not to have been examined till Mr Home was led to look for them, in conſequence of the above experiment. Mr Home varied this experiment, by giving animals a decoction of madder, and an infuſion of rhubarb, and obtained ſimilar reſults. Part of the fluid ſwallowed was again rejected by vomiting; but of that which remained it was always found that a part had eſcaped, without any poſſibility of paſſing by the *pylorus*, as this was ſecured by ligature. It did not probably eſcape by the abſorbents, as theſe were not ſo much diſtended by fluid as to be viſible; and it certainly did enter the ſpleen, as there was there found a quantity of liquor, which was proved, by an alkaline teſt, to contain rhubarb. A large quantity of urine was found in the bladder, alſo impregnated with rhubarb *.

* *Phil. Trans.* for 1808, p. 2.

277 Spleen carries off fluid from the ſtomach.

From theſe experiments it appears, that the ſpleen is capable of carrying off from the ſtomach, a part of its fluid contents, thus affording a much nearer paſſage to the bladder than through the abſorbents. If this inveſtigation, on further trials, ſhall prove equally ſatisfactory, it will explain why the bladder is often diſtended with urine in a ſhort time after drinking; and will do away the neceſſity of having recourſe to the diſputed hypotheſis of the retrograde action of the abſorbents.

278 Peculiar animal ſecretions.

In the inferior claſſes of animals there are a number of peculiar ſecretions, which, from their utility in medicine or the arts, or from their noxious or unpleaſant effects, are deſerving the attention of phyſiologiſts. We can here only mention a few of the more important. The nature and properties of moſt of them are explained under CHEMISTRY.

Some of the mammalia ſecrete matters that have a very ſtrong ſmell, as *muſk*, *civet*, *caſtor*, and in particular the fluid emitted from the hide of ſeveral of the weazel tribe, beſide the civet cat. *Ambergris* is ſecreted by ſome ſpecies of whales. Birds, eſpecially water fowls, ſecrete a large quantity of oily matter, which they uſe in dreſſing their feathers. Some reptiles, eſpecially the toad, ſecrete an acrimonious fluid, which ſeems to ſerve them as a weapon of defence. Many ſerpents, as is well known, produce a moſt virulent poiſon, which they inſert into the wounds inflicted by their fangs. Some fiſhes ſecrete fluids of a ſimilar tendency. Few animals, however, form ſecretions ſo various and ſo uſeful, as the inſect tribes, from whom we procure *cochineal*, *kermes*, *lac*, *ſilk*, &c. Some of the molluſca, as the muſcle, and the ſpinning ſlug, alſo ſecrete a matter ſimilar to ſilk, by means of which they either ſecure themſelves firmly in their ſituations, or facilitate their progreſſive motion. The *ink* of the *cuttle fiſh*, ſuppoſed with no ſmall probability, to be the baſis of Indian or Chineſe ink, is alſo a remarkable animal ſecretion, which ſeems intended by nature to ſcreen the animal, and aſſiſt it in eluding the vigilance of its purſuers.

279 Vegetable ſecretions.

There are alſo many important vegetable ſecretions, conſtituting what are called *gums*, *reſins*, and *gum-reſins*; as *gum-arabic*, *gum-dragant*; *guaiac*, *dragon's blood*; *aſſafoetida*, *gamboge*, *myrrh*, *aloes*, and many others; for an account of which ſee CHEMISTRY and MATERIA MEDICA.

CHAP. XI. *Of Excretion.*

280 Excretion.

THE function of excretion differs but little in its nature from that of ſecretion already conſidered. As the organs of ſecretion ſeparate from the blood thoſe ſubſtances which are uſeful in the animal economy, ſo the excretory organs ſeparate from the blood, or from the food taken into the ſtomach, thoſe ſubſtances which are to be conveyed out of the body as excrementitious, viz. the ſolid excrement, the urine, and perſpiration.

281 Organs.

The organs of excretion, then, are chiefly the bowels, eſpecially the larger inteſtines, the kidneys, with their appendages, Of Excretion.

appendages, the ureters and urinary bladder, and the ſkin. For an account of theſe in the human body, ſee ANATOMY, Part I.; and for the varieties of theſe organs in ſuch of the inferior animals as poſſeſs them, and for the means by which their abſence is ſupplied in others, ſee the works of Cuvier and Blumenbach already quoted.

282 Excretion by the inteſtines.

The phyſiology of inteſtinal excretion requires little explanation. The remains of the food, after the nutritious chyle has been extracted from it by the lacteals, are carried onward through the colon and rectum by the periſtaltic motion of the inteſtinal canal, excited to action by the ſtimulus of their contents, and of the bile, and aſſiſted by the preſſure of the abdominal muſcles, till they reach the extremity of the rectum, when becoming more ſtimulant, partly by their bulk, and partly by their increaſed acrimony, they rouſe the muſcular fibres of that inteſtine to greater action, ſo as, with the aſſiſtance of the abdominal muſcles, to overcome the reſiſtance of the *ſphincter*, and are thus expelled.

283 Relations.

Inteſtinal excretion is influenced by moſt of the preceding functions. 1. By the nervous power; as we find that in caſes of paralyſis, the excrements are not paſſed without artificial means, or they are voided involuntarily. 2. By motion. Thus we find that the action of the bowels is increaſed by exerciſe, and leſſened by indolence and a ſedentary life; though the quantity of excrement paſſed is greater in the latter caſe than in the former, ſhewing that the ſtimulus of the excrementitious matter is not ſufficient without muſcular action, to produce the regular performance of this function. 3. By digeſtion. It is well known that the ſtronger the digeſtive powers of the ſtomach, the more active are the bowels, and again, when theſe latter are overloaded with excrement, the functions of the ſtomach are diſordered. 4. By ſecretion. The action of the inteſtines is increaſed, when that of the ſecretory organs which pour their contents into the alimentary canal, becomes unuſually great, viz. in unuſual ſecretions of bile or mucus, as in *cholera* and *diarrhœa;* while, when thoſe ſecretions are defective, as in caſes of *jaundice*, the inteſtines become unuſually torpid.

The morbid affections of inteſtinal ſecretion have been conſidered under MEDICINE, N° 109—112, and 114, 115.

284 Excretion by the kidneys.

The organs deſtined for the excretion of urine afford the moſt complete apparatus for this function of any that we ſhall have occaſion to notice, conſiſting of an aſſemblage of glands, collected within one membrane; an excretory duct; a reſervoir for collecting the excreted fluid, and a canal for conveying it out of the body. Indeed we may conſider the kidneys rather as ſecreting than excreting organs, as the urine there formed differs ſo much in its nature and properties from the circulating fluids. We know, by a deciſive experiment, that the kidneys perform the whole of this office, and that the other organs are intended for the excretion of the urine; for when the ureters are tied or obſtructed next the bladder, we find that the ſecretion of urine ſtill goes on, and that the ureters above the obſtruction ſoon become filled and prodigiouſly diſtended.

The nature and properties of urine, in its natural ſtate, and as altered in certain diſeaſes, have been conſidered under CHEMISTRY, N° 2670.

As the urine contains two ſubſtances that are not found in the blood, viz. *urea* and *uric acid*, Dr Thomſon concludes, on very probable grounds, that the office of the kidneys is not merely to ſeparate from the blood, a quantity of water and ſalts, but that they exert on this fluid ſome peculiar action, decompoſing ſome part of the blood, and forming ſome new ſubſtance or ſubſtances †.

† Thomſon's *Chemiſtry*, vol. v. 3d edit. p. 748.

285 Relations.

The mutual relations between this excretion and the preceding functions, are not many, or very important. During certain affections of the nervous ſyſtem, there is a ſudden and copious excretion of limpid urine, and ſome mental emotions produce an involuntary flow of it ‡. And in caſes of palſy, an incontinence, or a total ſuppreſſion of urine, is very common. This excretion is conſiderably influenced by motion, being leſs copious in thoſe who uſe much exerciſe, or lead a laborious life.

‡ *Merchant of Venice*, act iv. ſcene 1.

The morbid affections referable to this excretion, are noticed under MEDICINE, N° 118—122.

286 Excretion by the ſkin.

The excretion by the ſkin, or perſpiration, has exerciſed the ingenuity of many phyſicians and phyſiologiſts, ever ſince the time of Sanctorius; and though it is not now conſidered as ſo eſſential to life and health as it was in the beginning of the 18th century, is certainly of great importance. The quantity of watery fluid occaſionally thrown out by the ſkin in the form of ſweat, proves that, by means of this organ, the blood is freed from a great deal of uſeleſs or perhaps injurious matter, which could not ſo conveniently, or ſo perfectly, be expelled by other outlets. The nature of the matter perſpired, and the quantity of ordinary perſpiration, have been inveſtigated by many able experimentaliſts, the reſult of whoſe labours is given in the firſt volume of Johnſon's *Animal Chemiſtry;* the fifth volume (third edition) of Dr Thomſon's *Syſtem of Chemiſtry;* in a paper by Dr Kellie in the ſecond number of the *Edinburgh Medical and Surgical Journal*, and in our article CHEMISTRY.

The principal facts that have been aſcertained with reſpect to the perſpirable matter thrown out by the ſkin, relate either to its quantity, or its chemical compoſition.

287 Quantity of the perſpiration.

I. The experiments on the quantity perſpired, on which we can the moſt rely, are thoſe of Lavoiſier, Seguin, and Mr Abernethy. From theſe experiments we may deduce the following concluſions: 1. The greateſt quantity of matter perſpired in a minute, amounts to about 26 grains troy, the leaſt to about 9 grains; giving an average of about 17 grains in the minute, or about 52 ounces in 24 hours. Dr Kellie eſtimates the quantity at about 30 ounces, which ſeems too ſmall. 2. The quantity of perſpiration is increaſed by drink, but not perceptibly by ſolid food. 3. Perſpiration is the leaſt in quantity immediately after a meal, and reaches its higheſt proportion during digeſtion.

288 Its compoſition.

II. The perſpirable matter is chiefly compoſed of a large quantity of water, ſome carbon or carbonic acid, a ſmall quantity of another acid, ſuppoſed to be the phoſphoric, and a peculiar oily matter of an odorous quality, differing in different animals, and, as it ſhould ſeem, in different individuals. The perſpiration of quadrupeds is frequently found to contain phoſphate of lime, and ſometimes urea. See CHEMISTRY, N° 2532.

289 Relations.

As to the relations of perſpiration with the preceding functions, we may remark that this excretion is increaſed by various paſſions of the mind, by exerciſe, by healthy and rapid digeſtion; that it is generally in proportion to the vigour and quickneſs of the circulation and reſpiration, and that it is capable of ſupplying the defect of the two former excretions. On the contrary, Of Integumation.

it is lessened by inactivity; by the impaired state of the digestive organs; by languid circulation and respiration, and by violent purging, or evacuation of urine.

Chap. XII. *Of Integumation.*

290 Uses of integuments as defence.

All living bodies are furnished with integuments, which are intended to afford them a defence against those injuries to which their situation is commonly exposed. Of the integuments some are useful in preventing the dissipation of the fluids; some in resisting acrid and corrosive substances; some of them are indigestible in the stomach of animals, and some appear to be incorruptible in the earth. By these properties, seeds and the ova of insects are preserved for a considerable time, waiting the changes of soil or of season that are favourable to their evolution. They are protected from the action of weak membranous stomachs, and thus the animals who may swallow them contribute to their propagation. It is thus the seeds of the misletoe are dispersed, and deposited on the bark of the oak or the ash. There is a gelatinous substance frequently ejected by birds, and commonly called *tremella*, *nostoc*, or star-fall, which Dr Barclay has proved to be nothing else than the oviducts of frogs, which, as the embryo in form of an egg, moves along their winding canal, secrete that transparent and viscid matter which constitutes the albuminous part of the ovum, and feeds and protects the embryo while in water.

The most important circumstances with respect to integumation relate to the varieties of the integuments themselves, and to the changes or renovation of these in different animals.

291 Integuments useful by their hardness;

I. Some integuments are useful, chiefly from their strength and hardness. The *elytra* or shelly coverings of the beetle tribes afford an excellent defence for their membranous wings, when folded up; the shell of the snail lodges the intestines, when the animal comes forth to search for food, and affords a safe retreat to the animal, when it is threatened with any danger from without. The shells of some animals can be opened and closed by a muscular power; and some of them, as in the tail of the lobster, are so disposed in plates or scales, as to be no hindrance to the animal's motion. Several insects which pass a part of their time in the water, always compose for themselves a shell, where it is needful.

292 by their external covering;

Some integuments are covered with feathers, some with hair or thick down. Besides many other obvious uses of these coverings, they generally serve to repel insects; and being bad conductors of heat, tend to preserve an equal and necessary temperature. Some integuments are covered with prickles, which oppose the attacks of an enemy by the strength of their points, or by the venom which they infuse, as in the stings of nettles, and the down of some other plants, and some insects. Others again are moistened by a viscid secretion, which preserves the necessary softness of the parts, prevents evaporation, resists acrimony, enables some beings to destroy their enemies, and assists others in performing their progressive motions.

293 by their effluvia;

Both plants and animals, but particularly the former, are often protected by odorous effluvia from their integuments. These effluvia are the finer parts of their volatile oil, always inflammable, and so subtile, that the continual emission of it from wood or flowers does not sensibly diminish their weight. To this fragrance it is owing, that the deadly nightshade (*atropa belladonna*), the henbane, hounds-tongue, and many others, are seen on almost every high road untouched by animals. The manchinelle-tree of the West Indies emits so very dangerous vapours, that the natives poison their arrows with its juices, and those have died who have ventured to sleep under its shade. The *lobelia longiflora* of America produces a suffocating oppression in the breast of those who respire in its vicinity. The return of a periodical disorder has been attributed to the exhalation of the *rhus toxicodendron*. Of all the vegetable effluvia, however, that afford defence to the plant from which they proceed, or annoyance to the animals that approach it, none are equal to those of the celebrated *bohun-upas*, or poison-tree of Java, whose exhalations have been said to extend to the distance of several miles, preventing all access of animals, or punishing the intruders with certain death. It is rather unfortunate for the botanical poets, that the effects of this poison have been greatly exaggerated, if indeed such a marvellous tree really exists *.

* See *Pinkerton's Geography*, under *Java*.

294 by their colour.

Various colours of the integuments afford a species of defence. Caterpillars which feed on leaves are generally green; and earth worms the colour of the earth which they inhabit. Butterflies which frequent flowers are coloured like them. Small birds which frequent hedges have greenish backs like the leaves, and light-coloured bellies like the sky, and are hence less visible to the hawk who passes under them or over them. Those birds which are much amongst flowers, as the goldfinch, are furnished with vivid colours. The lark, partridge, and hare, are of the colour of dry vegetables, or earth on which they rest; and frogs vary their colour with the mud of the streams which they frequent, and those which live on trees are green. Fish which are generally suspended in the water, and swallows which are generally suspended in the air, have their backs the colour of the distant ground, and their bellies of the sky. The *sphinx convolvuli*, or unicorn moth, resembles in colour the flower on which it rests; and among plants, the nectary and petals of the *ophrys*, and of some kinds of the *delphinium*, resemble both in form and colour the insects which plunder them, and thus sometimes escape from their enemies by having the appearance of being pre-occupied. From colour being thus employed as a defence, many animals vary their colours with the seasons and circumstances; and those which are of different colours in summer according to the places which they inhabit, in winter assume in common the colour of the snow.

295 Change of integuments.

II. The changes that take place on the integuments consist either of a partial, or complete, renewal of them. As the more superficial integuments are commonly insensible to stimuli, and possess little or nothing of the vital principle; in all cases where they cannot be enlarged to admit of an additional increase of growth, or, where they are not furnished with organs for repairing those injuries which they may suffer from accident or disease, the body is endowed by nature with a power of throwing them off, and of producing others in their stead. Thus, serpents and toads slough their skins; the crustacea cast their shells; the larvæ of insects change their cuticle; and several trees, especially the

Of Transformation.

the cork tree, throw off their outer bark. Even man himſelf generally changes the cuticle, which peels off in the form of ſcales. Moſt animals once a year change their hair, wool, or feathers, and have theſe renewed by a freſh covering; a proceſs well known by the name of *moulting*. Some animals who do not uſually caſt their external covering, have the power of repairing this when injured. This is the caſe with moſt of the teſtacea, eſpecially ſnails.

Chap. XIII. *Of Transformation.*

296 Transformation.

The alterations which organized beings undergo from *metamorphoſis* or transformation, are more ſtriking than thoſe which we have deſcribed in the preceding chapter. It has indeed been aſſerted, that theſe alterations conſiſt in throwing off certain temporary coverings; but this expreſſion is inaccurate, and ariſes from a want of preciſion of ideas. Transformation and change of integuments are really different; the truth is, transformation often takes place without any change of integuments, and there is often a change of integuments without any change of form. This new form is ſometimes occaſioned by a change of ſhape, conſiſtency, and colour, as when the lobes of a ſeed are converted into ſeminal leaves. It is at other times occaſioned by a change of proportion among the parts, and at others by the addition of new organs, as when the emmet receives wings, and the plume of the ſeed is fed by new roots ſtriking into the ground: or, laſtly, it is occaſioned by a change in the form and organs, and in their mode of operation, as happens in a remarkable degree to ſome inſects. Indeed, though all living bodies, both plants and animals, undergo ſome degree of transformation in the courſe of their exiſtence, theſe changes are moſt remarkable in inſects.

297 Transformation of reptiles;

Many reptiles undergo very curious changes, but theſe are moſt remarkable in the frog tribe. The larva or tadpole, as it is called, of the frog, is an animal with a large head, a long tail, no limbs, and commonly poſſeſſed of gills, all obviouſly very different, both in form, proportion, and uſes, from the parts of the perfect animal. The curious appearance of what has been conſidered as the tadpole of the *rana paradoxa*, has led ſome naturaliſts to deſcribe it as an animal of a different genus, either a fiſh or a lizard; ſee Erpetology, p. 284.

298 of inſects.

Many inſects appear to conſiſt of two diſtinct animal bodies, one within the other; the exterior, a creature of an ugly form, reſiding in the water, or under the earth, breathing by gills, or ſometimes by tracheæ projecting from the tail, poſſeſſing a voracious and grovelling appetite, and having a ſyſtem of ſanguiferous veſſels that circulates the blood towards the head. When all its parts decay and fall off, the creature incloſed ſucceeds in its ſtead: this often is an animal of a different form, generally lives in a different element, feeds on a different ſpecies of food, has different inſtruments of motion, different organs of ſenſe, different organs of reſpiration and differently ſituated; and being endowed with the parts of generation, inclines to gratify the ſenſual propenſity, and produces an embryo, which becomes like the firſt, and from which, in proceſs of time, a creature is evolved ſimilar to the former.

If the embryo or egg be depoſited on a leaf, the leaf is frequently obſerved to bend, to wrap it in folds, intended for the purpoſe of protecting it from injuries and danger. If depoſited in the body of an animal or plant, they accommodate themſelves to its wants and neceſſities, and furniſh a tumor which ſerves it for a nidus, and beſides, like an uterus, ſupplies it with nouriſhment; and if depoſited in the body of an inſect, the creature provides for the future deſtination of its young charge with all the tender care of a parent, and then dies.

299 Parents of inſects often not eaſily diſtinguiſhed.

Theſe circumſtances, added to the great variety of forms which inſects aſſume, render it ſometimes difficult to know who is the parent. We cannot, for inſtance, pronounce with certainty who is the true parent of the gordius, known by the name of the *ſeta equina*, or hair eel. A ſet of experiments which Dr Barclay once began with a view to throw ſome light on the ſubject, were unfortunately interrupted by an accident. He learned only, from a number of obſervations, that certain black beetles, at the end of ſummer, have the ſtrongeſt propenſity to run into the water, where they ſoon die; and that one or two, and ſometimes three or four of thoſe eels gradually drop from the beetle by the anus. Whether other inſects provide for the gordius in this manner, we have not yet been able to determine.

300 Transformation accompanied by change of propenſities.

In all living bodies poſſeſſed of a *ſenſorium*, the changes of form, as well as the changes of habit and of age, are uſually accompanied with new propenſities, appetites, and paſſions.

301 Conſiſts in the evolution of parts.

Microſcopic obſervations having demonſtrated, that all the forms of the plant and animal exiſted previouſly in the ſeed or embyro; transformation muſt be owing entirely to the evolution of the different parts by means of nutrition.

302 Its uſes.

What nature intends by transformation, we cannot determine; but by means of it different elements are peopled, the different ſeaſons variouſly adorned, and animated nature wonderfully diverſified without a multiplication of beings.

Chap. XIV. *Of Reproduction.*

303 Reproduction of parts,

In the preſent chapter we ſhall notice, firſt, the partial reproductions that take place in ſome claſſes of animals, and then take a general comparative view of the principal phenomena of generation, in the various claſſes of living beings.

304 In man and *mammalia*.

Experiments have proved, that even in the ſuperior claſſes of animals, many parts of the body, when deſtroyed or removed, may be reproduced. A bone may be broken in ſuch a manner, that part of it muſt be taken away, but in a few weeks the ſeparated ends are brought together by the ſecretion of new bony matter, called *callus*. Little more than 24 hours have elapſed after a fracture, before nature begins her operations. The ſoft parts inflame; the perioſteum becomes ſwelled; the veſſels pour out coagulable lymph, and a pellucid, gelatinous ſubſtance appears about the broken extremities of the bone. Into this minute blood-veſſels are gradually ſent off from the arteries, and in no very long time phoſphite of lime begins to be ſecreted, for rendering the whole firm and compact. In caſes of *necroſis*, where the old bone entirely loſes its vitality, new bony matter is ſecreted into the ſurrounding perioſteum, which thickens and enlarges, and in time ſupplies the place of the old bone. When a muſcular part is cut away, as in removing fleſh that

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that has become gangrenous, if the healthy function of the surrounding parts can be restored, and the loss of flesh has not been too great, the wound gradually fills up, not indeed with fleshy fibres, but with granulations very much resembling the ordinary cellular substance. It is well known, that the hair, nails, and skin, are occasionally renewed; but it will appear extraordinary that blood-vessels, and even nerves, have been reproduced. In cases of aneurism, where the trunk of the diseased artery is divided, so as to cut off the usual channel for the blood, the anastomosing branches become gradually enlarged, and even new branches appear to be formed for carrying on the circulation. What has been said above respecting the formation of *callus*, also proves the formation of new blood-vessels; and the observations of Mr John Hunter put this beyond a doubt. Till within these few years, it was thought impossible that a divided nerve should re-unite; but some late experiments of Mr Cruikshank have proved that this re-union may take place *.

* *Phil. Trans.* 1795, p. 177.

Under this head we may mention some curious experiments that have been lately made by Dr Jones, on the means by which nature suppresses the hæmorrhage from divided arteries. These experiments were made on dogs, and the results of them lead us to conclude, that the following is nearly the process by which the hæmorrhage is suppressed. First, the divided artery contracts, and is drawn within the neighbouring parts; blood is gradually effused into the sheath of the artery and the adjoining cellular substance, where it is entangled, and affords a basis for the formation of a coagulum or clot, which surrounds the extremity of the divided artery, and prevents the farther effusion of blood, till another clot is formed within the mouth of the artery, plugging it completely up. Soon after there oozes out between the external and internal clot, a quantity of coagulable lymph, which cements all the parts together, and thus in time, if the artery divided be not very large, and the force of the circulation very great, the cavity of the vessel and the divided extremity, is obliterated, and all further loss of blood effectually prevented †.

† *Jones's Treatise on Hæmorrhages*, &c.

305 Reproduction of parts, in the inferior animals;

It is, however, in the lower classes that we are to look for the most remarkable instances of this provision of nature, particularly among the reptiles, crustacea, mollusca, worms, and polypes.

306 in reptiles;

In many reptiles, the legs and tail, when cut off, are soon renewed, and even the eyes have been re-produced. Some interesting experiments on this subject by Spallanzani have been related under ERPETOLOGY, p. 316, to which we refer the reader.

307 in crustacea;

In the crustacea, the legs and claws are very often torn away, either by accident, or by some voracious animal; but these never fail to be renewed in a short time, provided the animal is in good health. This is most remarkable in the craw-fish (cancer astacus, Lin.). It has been observed that when the claw of this animal is broken, the most distant part is gradually cast off, and about a day or two after, a red membrane, not unlike a bit of red cloth closes up the aperture. This is at first plain; but in the course of four or five days it assumes a convexity, which gradually augments till it takes the appearance of a small cone, which exceeds not a line in height. It continues, however, to stretch out, and in ten days it is sometimes more than three lines, or about one-fourth of an inch high. It is not hollow, but filled with flesh, and this flesh is the basis or rudiment of a new claw. The membrane that covers the flesh performs the same office to the young claw as the membranes do to the fœtus of the larger animals. It extends in proportion as the animal grows; and as it is pretty thick, we can perceive nothing but a lengthened cone. When 15 days are elapsed, this cone inclines towards the head of the animal. In a few days more its curvature increases, and it begins to assume the appearance of a dead claw. This claw, though at the end of a month or five weeks it has acquired the length of six or seven lines, which is more than half an inch, is still incapable of action. The membrane in which it is enclosed becoming gradually thinner, in proportion as it extends, gives an opportunity of observing the parts of the claw, and we now perceive that this conical substance is not a simple congeries of flesh. The moment is now arrived when the claw begins to be brought forth. The membrane at last bursts, and the new claw, though still soft, appears without incumbrance or investment. In a few days more it is covered with a shell; and though still delicate, and not the half of its former length, it is able to perform all the natural functions. It has likewise been discovered, that, whether the claw has been lopped off at the fourth articulation, or anywhere else, the animal in a short time recovers all that it had lost. The same reproduction takes place also in the horns; but, if the tail is cut off, the animal survives a few days only *.

* *Bingley's Animal Biog.* vol. iii.

308 in mollusca;

Many of the mollusca exhibit curious instances of reproduction, especially the actinia, the star-fish, and snails. The Abbé Dicquemaire made several experiments to ascertain the reproductive power of the *actinia rufa* (purple sea anemony). He first cut off all its tentacula, which grew again in less than a month; and on repeating this a second and third time, he had equal success. He cut off the upper part of one, and a few days after, the base of the animal was found to have fallen from its place; but it soon entirely recovered its limbs. But if the base of these animals is injured by the incision, the wound commonly proves mortal. The arms of the star-fish are often torn off, but appear always to be reproduced. The power of snails in this respect is very great; for Spallanzani has ascertained, that even if their heads are cut off, these are regenerated in no very long time. There can scarcely be a more surprising instance of animal reproduction than this, as we shall readily allow, if we consider the complicated structure of the head of a snail; that it contains a brain divided into two parts; that the horns attached to it are furnished with muscles, and that on the tops of the larger horns there are eyes, composed of two coats and three humours; that the head contains a mouth, lips, teeth, and a palate; and yet all these parts, when cut away, have been reproduced in the course of a few weeks.

309 in polypes.

On the reproductive power of polypes we have been sufficiently minute under HELMINTHOLOGY, N° 84.

310 Writers on the re-production of parts.

As this subject of partial reproduction is extremely curious, and as we cannot here enter upon any particular detail on the experiments and observations that have been made on the subject, we shall conclude this part of the present chapter by enumerating the principal works to which the reader may refer for a more satisfactory account of the subject. These are chiefly Trembley, Of Reproduction. bley, *Memoires sur les Polypes;* Bonnet, *Traité d'Insectologie, Palingenesie,* and *Considerations sur les Corps Organisés*, vol. ii.; Reaumur, *sur les Insects;* Spallanzani, *Tracts on Animals and Vegetables*, and *Essay on Reproduction;* Hunter's *Treatise on the Blood*, &c.; Russel's *Practical Essay on Necrosis* Moore *on the Healing Process;* Murray, *de Redintegratione Partium;* and the publications of Dr Jones and Mr Cruikshank already referred to. There is also a neat view of the principal facts relating to this subject in a thesis *De Vulnere Naturæ Sanándo*, published at Edinburgh in 1805, by Dr John Gordon.

311 Reproduction of the species by generation. We have already stated it as our opinion, that plants, as well as animals, reproduce their like by generation. We shall not now enter on a discussion of the controverted point of the sexual system; and as the parts that appear subservient to this function in plants, and their various modes of propagation, have been sufficiently explained under the articles BOTANY and PLANT, we shall in this chapter confine our attention to the generation of animals.

312 Organs. The human organs of generation are described in the article ANATOMY, sect. xv. those of the cetacea under CETOLOGY, N° 161.; those of birds under *Comparative* ANATOMY, 277: those of fishes have been noticed under ICHTHYOLOGY. For a more full comparative view of these organs, we refer to Cuvier and Blumenbach.

313 Nature of generation. The nature of generation which is the greatest mystery in the economy of living bodies, is still involved in impenetrable obscurity. The only circumstance common to all generation, and consequently the only essential part of the process, is, that every living body is attached at first to a larger body of the same species with itself. It constitutes a part of this larger body, and derives nourishment, for a certain time, from its juices. The subsequent separation constitutes *birth*, and may be the simple result of the life of the larger body, and of the consequent developement of the smaller, without the addition of any occasional action.

Thus the essence of generation consists in the appearance of a small organized body in or upon some part of a larger one; from which it is separated at a certain period, in order to assume an independent existence.

All the processes and organs, which co-operate in the business of generation in certain classes, are only accessory to this primary function.

314 Gemmiparous generation. When the function is thus reduced to the most simple state, it constitutes the gemmiparous, or generation by shoots. In this way the buds of trees are developed into branches, from which other trees may be formed. The polypes (hydra) see HELMINTHOLOGY, N° 84. and the sea anemones (actiniæ), multiply in this manner; some worms are propagated by a division of their body, and must, therefore, be arranged in the same division. This mode of generation requires no distinction of sex, no copulation, nor any particular organ.

315 Fecundation. Other modes of generation are accomplished in appropriate organs; the germs appear in a definite situation in the body, and the assistance of certain operations is required for their further developement. These operations constitute *fecundation*, and suppose the existence of *sexual parts;* which may either be separate, or united in the same individual.

In most animals the embryo of the future young is fecundated within the peculiar organs of one individual, while another of the same species is provided with the means of giving activity to the embryo by a fecundating fluid. In some animals, however, both these offices are performed by the same individual, which is then said to be androgynous, or hermaphrodite.

316 Distinction of sexes. The office of the male sex is that of furnishing the *fecundating* or *seminal fluid;* but the manner in which that contributes to the developement of the germ is not yet settled by physiologists. In several instances, particularly in the frog, the germ may be clearly recognized in the ovum before fecundation; its pre-existence may be inferred in other cases from the manner in which it is connected to the ovum when it first becomes visible; for it is agreed on all hands, that the ovum exists in the female before fecundation, since virgin hens lay eggs, &c.

317 Hermaphrodites. The combination of the sexes and the mode of fecundation are subject to great variety. In some instances they are united in the same individual, and the animal impregnates itself. The acephalous mollusca and the echini exemplify this structure. In others, although the sexes are united in each individual, an act of copulation is required, in which they both fecundate, and are fecundated; this is the case with the gasteropodous mollusca and several worms. In the remainder of the animal kingdom the sexes belong to different individuals.

318 Modes of impregnation. The fecundating liquor is always applied upon or about the germs. In many cases the ova are extruded before they are touched by the semen, as in some bony fishes and the cephalopodous mollusca. Here, therefore, impregnation is effected out of the body, as it is also in the frog and toad. But in the latter instances the male embraces the female, and discharges his semen in proportion as she voids the eggs. In most animals the seminal liquor is introduced into the body of the female, and the ova are fecundated before they are discharged. This is the case in the mammalia, birds, most reptiles, and some fishes; in the hermaphrodite gasteropodous mollusca, in the crustacea, and insects. In all the last mentioned orders ova may be discharged without previous copulation, as in the preceding. But they receive no further developement; nor can they be fecundated when voided *. We shall not gratify the prurient imagination of the philosophic sensualist, by any details of the mode in which these operations are carried on in the various classes of animals, except in one instance, which is so curious that we shall be excused for describing it. We allude to the copulation of the snail.

* Cuvier *Leçons d'Anat. Comp.* tom. v. p. 12.

319 Copulation of snails. These animals meet in pairs, and stationing themselves an inch or two apart, launch several little darts, not quite half an inch long, at each other. These are of a horny substance, and sharply pointed at one end. The animals, during the breeding season, are provided with a little reservoir for them, situated within the neck, and opening on the right side. On the discharge of the first dart, the wounded snail immediately retaliates on its aggressor by ejecting at it a similar dart; the other again renews the battle, and in turn is again wounded. Thus are the darts of Cupid, metaphorical with all the rest of the creation, completely realised in snails. After the combat they come together. Each of them lays its eggs in some sheltered and moist situ-

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tion, generally under a little clod of earth, or in some cool cavity †.

† Shaw's Naturalist's Miscellany, vol. i.

The effect of a single copulation varies in its degree: it usually fecundates one generation only; but sometimes, as in poultry, several eggs are fecundated; still, however, they only form one generation. In a very few instances one act of copulation fecundates several generations, which can propagate their species without the aid of the male. In the plant-louse *(aphis)* this has been repeated eight times; and in some *monoculi* 12 or 15 times.

320

321 Oviparous generation. When the germ is detached from the ovary, its mode of existence may be more or less complete. In most animals it is connected, by means of vessels, to an organized mass, and the absorption of which nourishes and developes it until the period of its birth. It derives nothing, therefore, from the body of the mother, from which it is separated by coverings varying in number and solidity. The germ, together with its mass of nourishment, and the surrounding membranes, constitutes an egg, or *ovum;* and the animals which produce their young in this state, are denominated *oviparous.*

In most of these the germ contained in the egg is not developed until that part has quitted the body of the mother, or has been *laid;* whether it be necessary that it should be afterwards fecundated, as in many fishes; or require only the application of artificial heat for its incubation, as in birds; or that the natural heat of the climate is sufficient, as in reptiles, insects, &c. These are strictly oviparous animals.

322 Ovo-viviparous animals. The ovum, after being fecundated and detached from the ovarium, remains in some animals within the body of the mother, until the contained germ be developed and hatched. These are *false viviparous* animals, or *ovo-viviparous.* The viper, and some fishes, afford instances of this process. Mammalia alone are truly viviparous animals.

323 Viviparous generation. Their germ possesses no provision of nourishment, but grows by what it derives from the juices of the mother. For this purpose it is attached to the internal surface of the uterus, and sometimes, by accident, to other parts, by a kind of root, or infinite ramification of vessels, called *placenta.* It is not, therefore, completely separated from the mother by its coverings. It does not come into the world until it can enjoy an independent organic existence. The mammalia cannot, therefore, be said to possess an *ovum* in the sense which we have assigned to that term.

From this view of the subject, generation may be said to consist of four functions, differing in their importance, and in the number of animals to which they belong.

1. The *production of the germ,* which is a constant circumstance; 2. *Fecundation,* which belongs only to the sexual generation; 3. *Copulation,* which is confined to those sexual generations, in which fecundation is accomplished within the body; 4. *Uterogestation,* which belongs exclusively to viviparous generation *.

* Cuvier, lec. xxix.

There is a general rule observable among all quadrupeds, that those which are large and formidable produce but few at a time; while such as are mean and contemptible are extremely prolific. The lion, or tiger, have seldom above two cubs at a litter; while the cat, that is of a similar nature, is usually seen to have five or six. In this manner, the lower tribes become extremely numerous; and, but for this surprising fecundity, from their natural weakness, they would quickly be extirpated. The breed of mice, for instance, would have long since been blotted from the earth, were the mouse as slow in production as the elephant. But it has been wisely provided, that such animals as can make but little resistance, should have at least a means of repairing the destruction which they must often suffer, by their quick reproduction; that they should increase even among enemies, and multiply under the hand of the destroyer. On the other hand, it has as wisely been ordered by Providence, that the larger kinds should produce but slowly; otherwise, as they require proportional supplies from nature, they would quickly consume their own store; and, of consequence, many of them would soon perish through want; so that life would thus be given without the necessary means of subsistence. In a word, Providence has most wisely balanced the strength of the great against the weakness of the little. Since it was necessary that some should be great and others mean, since it was expedient that some should live upon others, it has assisted the weakness of one by granting it fruitfulness, and diminished the number of the other by infecundity.

324 Comparative fecundity of animals.

In consequence of this provision, the larger creatures, which bring forth few at a time, seldom begin to generate till they have nearly acquired their full growth. On the contrary, those which bring many reproduce before they have arrived at half their natural size. Thus the horse and the bull are at their best before they begin to breed: the hog and the rabbit scarce leave the teat before they become parents in turn. Almost all animals likewise continue the time of their pregnancy in proportion to their size (L).

For an account of the principal phenomena attending the reproduction of the human species, viz. the requisites for conception and its signs; the effects of impregnation; the gradual evolution of the fœtus, and the successive changes that take place in the uterine system during uterogestation, see the article MIDWIFERY, chap. i. and ii. The phenomena of reproduction in other viviparous animals are so analogous to those in the human species, that we need not enter on an examination of them. We shall here only give a view of the successive changes that take place in the egg of birds during incubation, taken from the observations of the celebrated Blumenbach. 325

326 Progressive changes of the chick during incubation.

The following observations refer to the egg of the common hen, as affording the most familiar example of incubation.

A small shining spot, of an elongated form, with rounded extremities, but narrowest in the middle, is perceived at the end of the first day, not in nor upon the

(L) In the following table are noted the time of gestation, incubation, and the number of young produced in several species of quadrupeds and birds, as far as these have been ascertained; and the second column shews the period to which the life of each is usually extended.

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the cicatricula (M), but very near that part on the yolk-bag. This may be said to appear before-hand, as the abode of the chick which is to follow.

327 Second day.

No trace of the latter can be discovered before the beginning of the second day; and then it has an incurvated form, resembling a gelatinous filament with large extremities, very closely surrounded by the amnion, which at first can scarcely be distinguished from it.

3 T 2 About

	Species.	Period of Life.	Time of Gestation.	Number of Young.
Quadrupeds.	Apes.	- - -	- - -	About 2.
	Bats.	- - -	- - -	From 2 to 5.
	Sloth.	- - -	- - -	One.
	Rhinoceros.	70 or 80 years.	- - -	One.
	Elephant.	Above 100 years.	21 months.	One.
	Arctic walrus.	- - -	9 months.	One.
	Seal.	- - -	- - -	About two.
	Bitch.	12 or 16 years.	9 weeks.	From 4 to 10.
	Wolf.	- - -	3½ months.	5 or 6.
	Fox.	About 14 years.	6 weeks.	From 3 to 6.
	Jackall.	- - -	- - -	From 6 to 8.
	Lioness.	Above 70 years.	- - -	4 or 5.
	Tigress.	- - -	- - -	Ditto.
	Cat.	From 10 to 18 years.	8 weeks.	From 4 to 6.
	Ferret.	- - -	6 weeks.	6 or 7.
	Otter.	- - -	9 weeks.	4 or 5.
	Virginian opossum.	- - -	- - -	Ditto.
	Kanguroo.	- - -	- - -	One.
	Mole.	- - -	- - -	4 or 5.
	Porcupine.	- - -	- - -	Two.
	Guinea pig.	6 or 7 years.	3 weeks.	From 5 to 12.
	Common rat.	- - -	5 or 6 weeks.	From 12 to 18.
	Mouse.	From 2 to 3 years.	- - -	From 6 to 10.
	Common squirrel.	- - -	6 weeks.	From 4 to 5.
	Hare.	- - -	A month.	3 or 4.
	Rabbit.	- - -	Ditto.	About 8.
	Camel.	40 or 50 years.	12 months.	One.
	Rein deer.	15 or 16 years.	8 months.	Two.
	Stag.	Near 50 years.	5 months.	One.
	Goat.	- - -	5 months.	About 2 or 3.
	Ewe.	15 years.	Ditto.	From 1 to 3.
	Cow.	- - -	9 months.	1 to 3.
	Mare.	30 or 40 years.	11 months.	1 or 2.
	Sow.	Nearly 20 years.	4 ditto.	From 10 to 20.
			Time of Incubation.	
Birds.	Eagle.	Above 100 years.	30 days.	2 or 3.
	Raven.	Near 100 ditto.	20 ditto.	5 or 6.
	Cuckoo.	- - -	- - -	1 or 2.
	Humming bird.	- - -	12 days.	Two.
	Blackbird.	- - -	14 ditto.	4 or 5.
	Canary bird.	10 or 20 years.	Ditto.	Ditto.
	Wren.	- - -	Ditto.	From 10 to 18.
	Pigeon.	- - -	Ditto.	Two.
	Turkey.	- - -	A month.	18 or 20.
	Hen.	About 13 years.	3 weeks.	About 20.
	Ostrich.	- - -	Six weeks.	One or two each.
	Swan.	Above 100 years.	Ditto.	6 or 8.
	Goose.	Near 100 years.	A month.	9 to 12.
	Duck.	- - -	Ditto.	12 to 14.

(M) The structure of an egg has already been described under the article EGG; but for the better understanding of Blumenbach's observations, it may be necessary to enumerate the several parts, with the names given to them by that author. The membrane lining the shell is called *membrana albuminis*, and includes the two whites of the egg, the inner of which surrounds the yolk, which is contained within a peculiar, very delicate membrane, called the *yolk-bag*. From two opposite sides of this bag proceeds a white knotty body, terminating in the white of the egg, by a flocculent extremity. These bodies are called the *chalazæ* or *grandines*; the *cicatricula*, tread, or traddle, is surrounded by one or more whitish concentric circles called *halones*, or *circuli*, the use of which is not known.

Of Reproduction. About this time the halones enlarge their circles; but they soon after disappear entirely, as well as the cicatricula.

The first appearance of red blood is discerned on the surface of the yolk-bag, towards the end of the second day. A series of points is observed, which form grooves; and these closing, constitute vessels, the trunks of which become connected to the chick. The vascular surface itself is called *figura venosa*, or *area vasculosa;* and the vessel by which its margin is defined, *vena terminalis*. The trunk of all the veins joins the *vena portæ;* while the arteries, which ramify on the yolk-bag, arise from the mesenteric artery of the chick.

328 Third day. On the commencement of the third day, the newly formed heart is discerned by means of its triple pulsation, and constitutes a threefold *punctum saliens*. Some parts of the incubated chicken are destined to undergo successive alterations in their form; and this holds good of the heart in particular. In its first formation it resembles a tortuous canal, and consists of three dilations lying close together, and arranged in a triangle. One of these, which is properly the right, is then the common auricle; the other is the only ventricle, but afterwards the left; and the third is the dilated part of the aorta.

About the same time, the spine, which was originally extended in a straight line, becomes incurvated; and the distinction of the vertebræ is very plain. The eyes may be distinguished by their black pigment, and comparatively immense size; and they are afterwards remarkable in consequence of a peculiar slit in the lower part of the iris.

329 Fourth day. From the fourth day, when the chicken has attained the length of four lines, and its most important abdominal viscera, as the stomach, intestines, and liver, are visible, (the gall-bladder, however, does not appear till the sixth day), a vascular membrane begins to form about the navel; and increases in the following days with such rapidity, that it covers nearly the whole inner surface of the shell, within the *membrana albuminis*, during the latter half of incubation. This seems to supply the place of the lungs, and to carry on the respiratory process instead of those organs. The lungs themselves begin indeed to be formed on the fifth day; but, as in the fœtus of the mammalia, they must be quite incapable of performing their functions while the chick is contained in the amnion.

330 Sixth day. Voluntary motion is first observed on the sixth day, when the chick is about seven lines in length.

331 Ninth day. Ossification commences on the ninth day, when the ossific juice is first secreted, and hardened into bony points. These form the rudiments of the bony ring of the sclerotica, which resembles at that time a circular row of the most delicate pearls.

At the same period, the marks of the elegant yellow vessels on the yolk-bag, begin to be visible.

332 Fourteenth day. On the fourteenth day the feathers appear; and the animal is able to open its mouth for air, if taken out of the egg.

333 Nineteenth day. On the nineteenth day it is able to utter sounds; and on the twenty-first to break through its prison, and commence a new life.

Blumenbach concludes his observations with a few remarks on those very singular membranes, the yolk-bag and the chorion, which are so essential to the life and preservation of the animal.

334 Remarks on the chorion. The chorion, that most simple yet most perfect temporary substitute for the lungs, if examined in the latter half of incubation in an egg very cautiously opened, presents, without any artificial injection, one of the most splendid spectacles that occurs in the whole organic creation. It exhibits a surface covered with numberless ramifications of arterial and venous vessels. The latter are of a bright scarlet colour, as they are carrying oxygenated blood to the chick; the arteries, on the contrary, are of a deep or livid red, and bring the carbonated blood from the body of the animal. Their trunks are connected with the iliac vessels; and, on account of the thinness of their coats, they afford the best microscopical object for demonstrating the circulation in a warm-blooded animal.

335 On the yolk bag. The other membrane is also connected to the body of the chick, but by a two-fold union, and in a very different manner from the former. It is joined to the small intestine, by means of the *ductus vitello-intestinalis*, and also by the blood-vessels, with the mesenteric artery and vena portæ.

In the course of the incubation the yolk becomes constantly thinner and paler, by the admixture of the inner white. At the same time innumerable fringe-like vessels with flocculent extremities, of a most singular structure, form on the inner surface of the yolk-bag, opposite to the yellow ramified marks, and hang into the yolk. There can be no doubt that they have the office of absorbing the yolk, and conveying it into the veins of the yolk-bag, where it is assimilated to the blood, and applied to the nutrition of the chick. Thus in the chick which has just quitted the egg, there is only a remainder of the yolk and its bag to be discovered in the abdomen. These are completely removed in the following weeks, so that the only remaining trace is a kind of cicatrix on the surface of the intestine *.

Many of the causes which contribute to the formation of a living body have hitherto eluded human research; may in all probability never be discovered; and perhaps are beyond human comprehension.

336 Theories of generation. Some philosophers, discovering the extreme divisibility of matter, and learning from the microscope that transformation is but the developement of certain parts that previously existed, have thence imagined that generation is somewhat analogous; that all organised bodies received their form at the beginning; that the first of every genus and species contained by involution the numberless millions of succeeding generations; and that the union of the two sexes gives only a stimulus, and brings into view forms that had existed since the world began.

337 Hypothesis of successive evolution.

338 Objections. By this hypothesis they have attempted to explain a thing that is unknown by what must remain for ever incomprehensible to the human mind in its present state. They absurdly appeal from observation to conjecture; and suppose that bodies which are originally brought into view, which are daily augmented, frequently repaired, and sometimes renewed by organic action, do nevertheless in their first formation require an effort superior to what omnipotence is able to perform by secondary agents. Had the supporters of this hypothesis considered that many herbaceous plants produce new flowers when

* Blumenbach's Comp. Anat. chap. xxvii.

when the firſt ſet are untimely cut off; that lobſters and many other animals renew their limbs, and that certain polypes can raiſe a ſtructure ſo perfectly reſembling a vegetable form as to puzzle the naturaliſt whether or not he ſhould claſs them under plants, they would ſurely not have preſcribed ſuch bounds to omniſcient wiſdom and almighty power, or declared with ſuch confidence what the Author of nature, to ſpeak with the vulgar, muſt neceſſarily perform by his own hands, or what he may intruſt to ſecondary cauſes regulated by his laws.

Theſe philoſophers will find it difficult to account in a very ſatisfactory manner for monſtrous productions, and for thoſe changes of ſtructure and of form which for a while continue hereditary from the influence of habit. They object to others, that all the parts of a living body are mutually dependent on one another, and that they muſt neceſſarily have been coeval, or have exiſted at once. But though every attempt that has yet been made to aſcertain which of the vital organs are prior and which poſterior in a living body has proved unſucceſsful, it has not been demonſtrated that either themſelves or their functions are coeval. It may, on the contrary, be plainly demonſtrated from obſervation, that the lungs and the ſtomach do not begin to perform their functions ſo early as the heart and the vaſcular ſyſtem; that even the heart and its ſyſtem perform their functions with ſome conſiderable changes, immediately after birth; that the vegetable tribes are without nerves; and that the brain and nerves in the animal kingdom perform more and more of their functions, according as the ſyſtem approaches towards maturity. It has even been ſhewn, that bones will unite; that the limbs of an animal continue to be nouriſhed without the nerves; that there is a principle of life in the blood; that the heart will act under other ſtimuli beſide that of nervous influence; and ſound logic does by no means require us to ſuppoſe, that the firſt action of the fœtal heart, or the *punctum ſaliens*, is owing to the influence of ſtimuli from the brain, or that the brain muſt have exiſted when the heart firſt moved. Although the minuteneſs and tranſparency of the parts may prevent us from ſeeing the firſt gradual formation of the embryo, yet every obſervation corroborates the opinion, that it is formed by ſecondary cauſes, and through the medium of organic powers.

339 Hypotheſis of Epigeneſis.

Moſt phyſiologiſts have believed, the certain inorganic particles are contained in the ſyſtem of one ſex or of the other, and that by the union of the ſexes theſe particles have become organiſed. It has, however, been aſked whether or not is the embryo formed by the joint operation of the two ſexes? or is it formed entirely by one, and brought into action by a ſtimulus from the other? The former of theſe queſtions ſuppoſes that each of the ſexes has a ſeminal fluid; that ſome mixture takes place in the uterus, and produces an embryo, in the ſame manner that a neutral ſalt aſſumes a certain and determinate form. The notion implies ſome general and confuſed ideas of chemical combination; but does not beſpeak a very clear underſtanding, profound reflection, or much acquaintance with the nature and properties of living bodies.

For a long time paſt the moſt rational phyſiologiſts have generally thought that the embryo is formed gradually and ſlowly in one or other of the two ſexes, not by chemical combination, but a ſyſtem of organs, directed by laws and prompted by ſtimuli, with many of which we are yet unacquainted. From the great Hippocrates to Fabricius and Harvey, the credit of furniſhing the fœtal embryo was almoſt univerſally given to the females of oviparous animals. Among the viviparous, appearances were ſuch, that the female was left to conteſt it with the male. At laſt the eclat of Leeuwenhoek's diſcoveries ſeemed to put an end to all doubts entertained upon the ſubject. He very plainly ſaw through his microſcope that very great profuſion of particles that move to and fro with amazing rapidity in the male ſemen. Upon this he embraced the doctrine of Hamme, who had ſeen them before, and ſuppoſed from their motions that theſe particles were not only animalcules, but the principles or rudiments of that animal in whom they were formed, and that they were depoſited in the uterus of the female only to be nouriſhed and augmented in ſize. 340 Embryo ſuppoſed to be derived from the male.

What raiſed objections againſt this theory was, that numerous animalcules were diſcoverable by the microſcope in other fluids, and that a vaſt profuſion of young embryos appeared in caſes where never more than one or two arrive at maturity. It was an objection to it, that ſome females had been impregnated, where the hymen remained unbroken, ſo that the impregnating fluid could have reached only the mouth of the uterus. Again, in frogs, fiſhes, and many other animals, the ova are not impregnated till after extruſion; and laſtly, Haller had obſerved the chick completely formed in eggs that had not been fecundated. 341 Objections.

It is now, we believe, pretty generally known, that the embryo does not commence its exiſtence in the cavity of the uterus. De Graaf obſerved it on its paſſage down the fallopian tube; he ſaw the place where it firſt began in the ovarium of the female, and caſes have occurred where it has miſſed the fallopian tube, where it has fallen into the abdomen, in which the placenta has been formed, and the fœtus has grown among the bowels.

From theſe facts it has been concluded, notwithſtanding ſome feeble objections, that the female ovaria contain the embryos in the form of eggs; that theſe eggs are brought into action by the ſtimulating power of the male ſemen, which is ſometimes thrown into the cavity of the uterus, ſometimes applied only to its mouth, and ſometimes ſprinkled on the eggs after they are extruded. For more on this ſubject ſee the article MIDWIFERY. 342 More probable that the embryo exiſts in the female.

A view of the relations between the preſent function and thoſe which we have before examined, is a ſubject of ſo delicate a nature, that we muſt not enlarge on it. The ſympathy between the reproductive and the nervous ſyſtems is well known. The effect which deſire has occaſionally produced on the brain is very great, madneſs being not unfrequently the conſequence, either of too much indulgence, or of total continence. We are of opinion that the influence of the fancy or imagination on the uterine ſyſtem has been over-rated, though the accounts given of monſters or deformed births, in conſequence of terror experienced by the mother, appear to be too well authenticated to warrant our total diſbelief in this influence. Too much indulgence in this appetite produces a debilitated ſtate, both of 343 Relations.

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the mental and bodily functions, and deprives the system of that natural stimulus which seems essential to the activity and vigour of the body in the male.

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344 Necessity of sleep.

We have already considered the active means by which the waste of the body is repaired; but all these would have little effect, and could not indeed be carried on for any considerable time, without some general relaxation of the system. This relaxation is brought about by sleep, in which the active functions find a repose from the labours which they have undergone during the day; and in this way the system is recruited more completely than by any other means.

345 Sleep, an affection of mind.

Sleep may be considered as an affection of mind, and therefore more properly a subject of metaphysical, than of physiological speculation. It is, however, generally treated of in systems of physiology; and it will be necessary to take notice of some circumstances respecting it. We shall chiefly consider the state of the body and mind during sleep, and some of the principal theories that have been contrived to account for it.

346 Phenomena of sleep.

Natural sleep returns at certain intervals, which, are, however, different in different animals. Most animals, and especially man, sleep only during the night, but most of the predacious species, as beasts and birds of prey, choose this time for their predatory excursions, and repose during the day. Sleep comes on with an unusual languor and lassitude; an aversion to motion; the mind becomes unfit for its usual exertions; and the desire of rest pervades the whole system. In particular, the extensor muscles lose their power of preserving the body in an erect posture; the eyelids involuntarily fall; the head bows forward; the joints bend, and the body sinks. During sleep, all the voluntary motions are in general suspended; but the involuntary actions of the heart and lungs proceed, though not so vigorously as in the waking state; the circulation and respiration being slower than usual. Most of the senses are also in a state of repose, especially those of feeling, smell, and probably of taste. Hearing is, in some animals, very acute during sleep, and they are thus enabled to escape any danger that threatens them. Some animals, as the hare, also sleep with their eyes open; and in most the impression of light, when the eyelids are raised, is very evident. The functions of digestion, absorption, and secretion, seem to proceed with greater ease and activity during sleep; and assimilation and nutrition are much promoted by this state of repose. Some of the faculties of the mind, especially the imagination, are, however, in full vigour, as appears from the dreams that take place during sleep. The duration of sleep is exceedingly various. Among the human species, young children, and very old persons, pass the greatest half of their time in sleep, while middle-aged and active people seldom sleep so much as one third of the 24 hours.

Though the returns of sleeping and waking depend much on custom, they may, however, be changed by various circumstances; and though the commencement of one of these periods happen to be altered, that of the other may remain as before. If a person is accustomed to go to sleep exactly at nine in the evening, and to rise again at six in the morning, though the time of sleep may be occasionally protracted till twelve, he will yet awaken at his usual hour of six: or if his sleep be continued by darkness, quietness, or similar causes, till the day be farther advanced, the desire of sleep will return in the evening at nine.

347 Theory of sleep.

Most of the causes that produce or prevent sleep, have been mentioned in the article Medicine, N° 94. As to the immediate cause, the opinions of physiologists are much at variance, and the theory of sleep is as little understood as that of any function of the animal economy.

348 Hypothesis of Haller.

According to Haller, sleep arises, either from a simple absence, deficiency and immobility of the spirits, or from compression of the nerves, and always from the motion of the spirits through the brain being impeded *. That sleep is, some how or other, connected with a compression of the brain, appears very probable, from the heaviness and coma that take place in cases where such a compression has evidently been produced; but how this compression acts has never yet been satisfactorily explained; and the obstruction that Haller supposes in the motion of the animal spirits, or nervous fluid, is gratuitous.

* *First Lines of Physiology*. §. 585.

349 Of Brown.

One of the fashionable doctrines of the present day respecting the immediate cause of sleep is, that this state is produced by an exhaustion of irritability or excitability. According to Brown, sleep succeeds a diminution of excitement, during which the excitability is either only so far diminished that it can be accumulated again, or so abundant, that the excess can be wasted, and in each case the excitement restored †.

† *Elem. Med.* §. 337.

350 Of Darwin.

Similar to this is the doctrine of Zoonomia, that sleep depends on an exhaustion of sensorial power. Dr Darwin thus characterizes perfect sleep: 1. The power of volition is totally suspended. 2. The trains of ideas caused by sensation proceed with greater facility and vivacity; but become inconsistent with the usual order of nature. The muscular motions caused by sensation continue; as those concerned in our evacuations during infancy, and afterwards in digestion, and in priapismus. 3. The irritative muscular motions continue, as those concerned in the circulation, in secretion, and respiration. But the irritative sensual motions, or ideas, are not excited; as the immediate organs of sense are not stimulated into action by external objects, which are excluded by the external organs of sense; which are not in sleep adapted to their reception by the power of volition, as in our waking hours. 4. The associate motions continue, but their first link is not excited into action by volition, or by external stimuli. In all respects, except those above mentioned, the three last sensorial powers are somewhat increased in energy during the suspension of volition, owing to the consequent accumulation of the spirit of animation ‡.

‡ *Darwin's Zoonomia*, vol. i. §. 18.

Thus, the immediate cause of sleep consists in the suspension of volition produced by the exhaustion of sensorial power; and hence, whatever diminishes the general quantity of sensorial power, acts as a remote cause of sleep.

Beside the insufficiency of these hypotheses to account for many circumstances that take place during sleep, we may remark, that this state is often produced when no exhaustion of irritability, excitability, or sensorial power, can be supposed to have taken place. Thus, the propensity to sleep often becomes irresistible from the effects of monotonous speaking, from stillness, darkness, or from

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from the ſameneſs of the ſcenery around us; and when one ſtimulus, after long application, can arrouſe no more, another ſtimulus that in ordinary caſes is leſs powerful, produces excitement, and keeps off ſleep; an evident proof that excitability or ſenſorial power have not been very far exhauſted.

351 Suppoſed ſleep of plants.

Plants have been ſaid to ſleep. At the approach of night, many of them are obſerved to change their appearances very conſiderably, and ſometimes even to ſuch a degree as ſcarcely to be known for what they are. Theſe changes happen principally to the leaves and the flowers. During the night, many leaves, according to the nature and genus of the plant, are ſeen to riſe up, to hang down, or to fold themſelves in various ways, for the protection of the flowers, the buds, the fruits, the young ſtems; and many flowers, to eſcape a ſuperabundance of moiſture, to hang down their mouths towards the earth, or to wrap themſelves up in their calices. Theſe phenomena are owing to ſtimuli acting from without; we may add, that moſt of the motions are performed at the joints where the leaves and petals articulate with the ſtem. A period of reſt is as neceſſary to plants as ſleep is to animals. The irritable principle cannot act long under the influence of the ſame ſtimulus, except at intervals, and the rapid growth obſervable in plants during the night, is a ſtrong proof that the organs employed in aſſimilation had been diſturbed in diſcharging their functions during the day, when expoſed to the action of heat and light and of other ſtimuli.

352 Dreaming.

In our general outline, we had propoſed introducing here an account of the phenomena of dreams, but we find that this ſubject has been ſo fully diſcuſſed under the article DREAM, that any additional remarks would be unneceſſary. To this article therefore we refer the reader.

Rules for the management of the body with reſpect to ſleep, ſcarcely come within our preſent province; but as we paſs ſo much of our time in this ſtate, during which we are ſometimes occupied in a very agreeable manner, while at others we are ſubject to moſt uneaſy ſenſations, it is a matter of conſiderable conſequence to take thoſe meaſures which may ſecure to us the former, and enable us to avoid the latter. We have ſeen few rules better adapted to thoſe purpoſes than thoſe of Dr Franklin; but as more important matter preſſes for inſertion within the circumſcribed limits to which we are reſtricted, we muſt refer our readers to the original paper, which is publiſhed in the late 8vo edition of *Franklin's Works*, vol. iii. p. 437.

353 Somnambuliſm.

In a few caſes, not only the imagination has a full range during ſleep, but the voluntary motions of the body, and even the exerciſe of ſome of the external ſenſes, are carried on with apparently as much perfection as when the perſon is awake. This ſtate is called *ſomnambuliſm*, or ſleep-walking, and is commonly conſidered as a variety of dreaming. Many ſurpriſing accounts have been given of ſleep-walkers. They have been known to riſe, dreſs themſelves, go out of doors, and ſometimes out of a window, from which they have climbed upon the roof of a houſe, dig in a garden, draw water from a well, ſaddle a horſe and ride ſeveral miles; maintain a rational and intereſting converſation, and even go through a laborious and difficult literary taſk; and after having performed theſe exploits, they have returned to their bed without being conſcious of what they had been doing. This want of conſciouſneſs appears from their remembering nothing when they awake, of what paſſed during their ſleep. It is diſputed whether ſomnambuliſts incur as much danger in the actions which they perform, as thoſe who are awake, in ſimilar circumſtances. We are inclined to think that the danger is much leſs in the former caſe, as ſleep-walkers ſeem entirely free from the terror which commonly attends the attempting of any hazardous enterpriſe when awake; ſuch as mounting to the roof of a houſe, climbing a ſteeple, &c. If ſuddenly awaked, however, while engaged in any of their hazardous actions, the danger is very great.

354 Reverie.

Dr Darwin conſiders ſomnambuliſm, not as a ſtate of ſleep or dreaming, but as a variety of reverie, carried to a morbid extent, ſo as to become a ſort of epileptic or cataleptic paroxyſm. In the ſtate of reverie, according to Dr Darwin, the irritative motions occaſioned by internal ſtimuli continue, thoſe from the ſtimuli of external objects are either not produced at all, or are never ſucceeded by ſenſation or attention, unleſs they are at the ſame time excited by volition; the ſenſitive motions continue, and are kept conſiſtent by the power of volition; the voluntary and aſſociate motions continue undiſturbed. He conſiders reverie as an effort of the mind to relieve ſome painful ſenſation, whence it is allied to convulſion and inſanity *.

* *Zoonomia*, vol. i. §. 19.

355 Torpor of animals.

The torpor that takes place in many animals during winter, appears to be ſo nearly allied to ſleep, that we ſhall conſider it in this chapter.

A great variety of animals of almoſt every claſs, retire during the cold of winter, to the receſſes of caverns, holes in old walls, hollow trees, or below the earth, where they remain in apparently a lifeleſs ſtate till the return of ſpring rouſes them from their trance. We ſhall here enumerate the different animals that have been known to undergo this ſtate of hibernation.

356 Hibernating mammalia.

Bats, eſpecially the *veſpertilio murinus*, *auritus*, and *v. noctula* (ſee MAMMALIA, N° 39); *bears*, eſpecially the brown and the polar bear, and the badger; the *hedgehog*, (*erinaceus Europeus*); ſeveral ſpecies of the mouſe and rat tribe, but more eſpecially the *hamſter* (*mus cricetus*), the *marmots*, eſpecially the *arctomys marmota*, (ſee MAMMALIA, N° 124); the *dormouſe* (*myoxus muſcardinus*.) Sheep appear capable of living for a conſiderable time in a torpid ſtate, as they have been known to remain alive for ſeveral weeks, buried under the ſnow.

357 Hibernation of birds;

It does not appear that birds in general are capable of undergoing this ſtate of exiſtence; but the inſtances of ſwallows that have been found in this ſtate in old walls and hollow trees, and even, as ſome affirm, below water, and have recovered life and activity on being expoſed to gradual warmth, are too well authenticated to admit a doubt, that theſe at leaſt ſometimes hibernate.

358 of reptiles and ſerpents;

Moſt reptiles and ſerpents paſs the winter in a ſtate of hibernation; but this is more particularly the caſe with the land tortoiſe (*teſtudo græca*), ſee ERPETOLOGY, p. 271; frogs, and thoſe lizards which inhabit cold climates.

359 of fiſhes;

It is not certainly known whether many ſpecies of fiſh become torpid in winter; but there is no doubt that ſeveral of them are ſuſceptible of this ſtate *; and we are told that in North America, eſpecially about Hudſon's bay,

* Reeve *Diſ. Inaug. de Animalibus Hiemeſopitis*, p. 10.

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bay, fishes are not unfrequently found included within a body of ice, and when exposed to gentle heat, have recovered life and motion.

360 Of insects.

Almost all insects remain, during the winter, in a torpid state. This happens principally to the chrysolites, and such grubs as cannot, in that season, procure their food.

361 Of man.

It will appear extraordinary that we should place man among the hibernating animals; and yet there seems little doubt, that even he is capable of having his life suspended for a considerable time, when exposed to those causes which bring about the torpidity of those animals that we have already mentioned. We are told of a woman who, in February 1789, remained eight days buried in the snow, and still recovered; and the case of the three women who remained for 37 days in a stable at Bergamoletto, that had been overwhelmed by an *avalanche*, or snow heap, with no other sustenance than the milk of a half-starved she goat, is well known. These instances, added to others of persons who have passed several weeks in a state of almost uninterrupted sleep, tend to prove that man himself may, under certain circumstances, continue in a torpid state.

362 Principal phenomena of hibernation.

During this state of torpidity, the animals scarcely appear to live; sensation seems altogether lost; their irritability is so much diminished, that they may be cut, torn, or even broken to pieces, without expressing any mark of feeling, or giving any sign of motion; digestion seems entirely suspended; the secretions and excretions are discontinued. Some of the functions, however, are carried on. Respiration and circulation, though very languid, and sometimes scarcely perceptible, appear to go on in a degree sufficient to preserve the existence of the animal; and the action of the absorbents seems to be very little diminished, as appears from the gradual absorption of the fat. If the animal is taken from its place of confinement, and exposed to a gentle heat, it gradually recovers all its faculties; but if carried back to its cell, it relapses into the state of torpidity.

363 Suspended animation of some animals.

The long suspension of animation, of which several animals are susceptible, appears still more extraordinary than the torpidity above described. The common hair worm (*gordius aquaticus*) may, when dried, be preserved for an indefinite length of time, and when put into water, gradually recovers its usual activity of motion. See HELMINTHOLOGY, N° 32. One of the most remarkable cases of this suspended animation is that related of the garden snail, of which the following curious account has been given in the Philosophical Transactions for 1774. Mr Stuckey Simon, a merchant in Dublin, whose father, a fellow of the Royal Society, and a lover of natural history, left to him a small collection of fossils and other curiosities, had amongst them the shells of some snails. About 15 years after his father's death (in whose possession they were many years), he by chance gave to his son, a child about 10 years old, some of these shells to play with. The boy put them into a flower-pot, which he filled with water, and the next day into a bason. Having occasion to use this, Mr Simon observed that the animals had come out of their shells. He examined the child, who assured him that they were the same he had given him, and said he had also a few more, which he brought. Mr Simon put one of them into water, and in an hour and a half after observed that it had put out its horns and body, which it moved but slowly, probably from weakness. Major Vallancy and Dr Span were afterwards present, and saw one of the snails crawl out, the others being dead, most probably from their having remained some days in the water. Dr Quin and Dr Rutty also examined the living snail several times, and were greatly pleased to see him come out of his solitary habitation after so many years confinement. Dr Macbride, and a party of gentlemen at his house, were also witnesses of this surprising phenomenon. Dr Macbride has thus mentioned the circumstance: "After the shell had lain about ten minutes in a glass of water that had the cold barely taken off, the snail began to appear; and in five minutes more we perceived half the body pushed out from the cavity of the shell. We then removed it into a bason, that the snail might have more scope than it had in the glass; and here, in a very short time, we saw it get above the surface of the water, and crawl up towards the edge of the bason. While it was thus moving about, with its horns erect, a fly chanced to be hovering near, and, perceiving the snail, darted down upon it. The little animal instantly withdrew itself into the shell, but as quickly came forth again, when it found the enemy was gone off. We allowed it to wander about the bason for upwards of an hour, when we returned it into a wide-mouthed phial, wherein Mr Simon had lately been used to keep it. He was so obliging as to present me with this remarkable shell; and I observed, at twelve o'clock, as I was going to bed, that the snail was still in motion, but next morning I found it in a torpid stote, sticking to the side of the glass."

The still more extraordinary instances that have been related, on what many have considered authentic testimony, of toads having been found inclosed in the trunk of a large tree, or within a solid block of stone, appear almost incredible; and yet if we consider that M. Herissant preserved toads in a state of suspended animation for 18 months, in boxes covered with a thick coating of mortar (see ERPETOLOGY, p. 286.); that the snails mentioned in the above quotation, must have lain for at least 20 years; and that flies have been recovered after being immersed for many months in Madeira wine, it is difficult to say how long this suspended animation may not be continued.

364 Hibernation of plants.

Similar phenomena take place in the vegetable creation. Most of those plants which survive one year, shed their leaves on the approach of winter; and, during this season, the motion of the sap ceases, and they have all the appearance of dead shrubs. The herbaceous tribes even die down to the roots, which, being mostly of the bulbous kind, afford shelter to the surviving germ; and are hence called, by botanists, the *hybernacula* of plants. On return of spring, the plant shoots anew from its winter's retreat, and flourishes with its former strength and beauty.

Some plants are even capable of having their vitality, or rather the exercise of all their functions, suspended, as in the *gordius* and the snail, for an indefinite length of time. *Mosses* have been kept in a dried state in a *hortus siccus* for many years, and have shown no sign of life, till they were moistened and exposed to air, light, and a moderate heat, when they have recovered all their powers, have erected their stems, shot forth new branches, and flourished as at first.

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365 Theory of torpor.

It is almost impossible, in the present state of our physiological knowledge, to give any rational theory of these phenomena. The torpor of animals has been attributed to exhausted excitability, or exhausted sensorial power; to the effects of habit, and to the effect produced on the brain by suspended or diminished respiration. The last of these, though not quite satisfactory, appears to us the most probable hypothesis. It has been ably defended and illustrated by Dr George Kellie, in a paper in which he relates a remarkable case of torpor from cold.

"The powers of voluntary motion and of sensation (says Dr Kellie), are known to depend immediately upon the conditions of the brain and nerves; if, therefore, we could discover in what manner these organs are affected by any of the preceding events, we should advance considerably towards the solution of the questions above stated. (*Namely, What is the order of succession between the diminished irritability of the heart, in consequence of the abstraction of caloric, and the complete torpor of the voluntary muscles and of the organs of sense, and how are the intervening effects connected?*) Were the inactivity of these organs the direct effect of their diminished temperature; did the torpor in no case happen, till the heat of the brain and nerves was reduced beneath the natural standard, there could be hardly ground for any farther inquiry. But, as it is not so, some other change, less direct, must have occurred, in consequence of the connection of the brain with, and its dependence upon, some other of the functions antecedently and more immediately affected; and this function I apprehend to be respiration, between which and the energies of the nervous system a very intimate connection is maintained, through the changes produced on the blood during the pulmonary circulation. This dependence of the brain upon the properties of the blood, maintained by respiration, is evinced by a great variety of observations. Whatever impedes the respiratory changes of the circulating fluid debilitates or destroys the powers of muscular motion, as the respiration of noxious gases, of reduced or rarefied atmosphere; while greater exertions of muscular powers call for, and give occasion to more frequent respiration, more rapid consumption of air, and greater changes of the blood; and the breathing of more effective gases, as of the nitrous oxide, increases the motive and sensitive powers of animals. That these effects depend immediately upon the properties of the blood, as modified by respiration, acting on the brain has, I think, been proved by the experiments of Bichat, who, in a masterly manner, has traced the mutual connection and dependencies of the vital functions in his admirable *Recherches Physiologiques sur la Vie et la Mort*. The transfusion or injection of venous blood into the carotids induced asphyxia or death, the instant it reached the brain; an effect which did not follow the similar transfusion of arterial blood from the carotid of another *. By these experiments, and by several other observations, he has shewn, that the asphyxia which so instantly follows impeded or suspended respiration is occasioned by the impression of dark, venous, unchanged blood upon the brain, and not, as has commonly been supposed, from this blood being incapable of stimulating the left side of the heart, which, on the contrary, continues to contract and to circulate the blood for some time after the voluntary functions are suspended; an observation confirmed also by Coleman and others.

* *Bichat, Recherches*, part ii. art. 7.

"Such then appears to be the connection between the functions of respiration and those of the brain. Now, in animals rendered torpid from cold, there are many observations which lead us to believe, that the immobility of the nervous system depends much, and very directly too, on the state of respiration.

"In the perfect torpor of the hibernating *amphibiæ*, respiration is completely suspended, and the consequent changes produced on the blood by that function totally prevented. This, which appeared from a variety of observations on the winter quarters of such animals found imbedded in mud, incased in ice, or closed up in opercula of their own construction, for the occasion of excluding the air, has been amply confirmed by the pointed experiments of Spallanzani, lately published by Senebier †.

† *Mem. on Respiration.*

"In every case of torpor from cold, where the respiration falls short of this complete suspension, it is at least more or less impaired. How much the torpid state depends on this condition of the respiratory functions, farther appears from observing, that hibernating animals, even those not of the amphibious order, warned by the approach of winter, instinctively or industriously seek situations unfavourable to perfect respiration, where this function may be either inadequately or not at all performed, as by premature and involuntary interment under ground, in old walls, in mud, at the bottom of lakes, &c. The instinct of these animals, too, has been finely imitated by experiment, illustrating at once the object of this instinct, and confirming the opinion here advanced of its tendency. Thus the dormant hamster was found to regain and preserve its activity, when freely exposed to a pure atmosphere, the temperature, at the same time, not exceeding that at which it had formerly become torpid, or at which it returned to that state when again secluded under ground ‡. These observations seem conclusive on this point, and, with those already brought forward confirming the general connection established between the properties of the blood, as modified by respiration, and the functions of the brain, render it, I think, highly probable, that the torpor of the voluntary powers, in the cases now under consideration, is the consequence of a limited and imperfect respiration, antecedently induced by diminished temperature.

‡ *Buffon's Nat. Hist.* by Smellie, vol. vii. p. 193.

"Observation, indeed, is more deficient on this point with regard to the higher orders of animals, and to men, who only occasionally become torpid from cold. Yet more than analogy, which is here very strong, leads me to believe that, even in these, the functions of respiration are much and necessarily affected. The examples of cattle and of men remaining long torpid, deeply buried under snow, are pretty direct and convincing proofs of this.

"If our induction from all these observations be admitted, we have the rudiments of a theory adequate to the explanation of the phenomena, in so far, at least, as the torpor of the voluntary powers is concerned.

"From the suspended or imperfect respiration, those changes, by which the blood is fitted for maintaining the activity of the sensorial system, are interrupted; this imperfect blood circulating slowly through the brain directly impedes its functions, and so debilitates the excitability of the motive and sensitive organs, that they become torpid. This enunciation may seem hypothetical; but let the proofs of the intimate connection between the respirable and sensorial functions be weighed; consider

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conſider alſo the interrupted reſpiration of hibernating and torpid animals, their inſtincts with regard to this, and the greater facility with which torpor is induced in a confined ſituation, which they naturally ſeek; and compare all theſe with the obſervations and experiments of Bichat on the effects of the immediate impreſſion of venous blood upon the brain, and you will perceive a connected ſyſtem, not entirely fanciful, a theory not without foundation and ſtrength, and which appears to me at leaſt to merit ſome attention *."

* *Edin. Med. and Surg. Jour.* vol. i. p. 308.

For further particulars reſpecting the torpidity or hibernation of animals, we refer the reader to Spallanzani's *Tracts on Animals and Vegetables;* White's *Natural Hiſtory of Selborne;* Barton's *Fragments of the Natural Hiſtory of Pennſylvania;* Pennant's *Arctic Zoology;* La Cèpede *on Oviparous Quadrupeds, as tranſlated by Kerr;* Townſon's *Tracts on Natural Hiſtory and Phyſiology,* and the *Inaugural Diſſertation of* Dr Reeve *de Animalibus Hieme Sopitis*, publiſhed at Edinburgh in 1803.

Chap. XVI. *Of Death.*

366 In the article Man, (N° 33. *to the end*) we have traced the progreſs of human life, from the *cradle* to the *grave;* and have briefly conſidered the phenomena and the conſequences of natural *death.* In that article, and Longevity, we have alſo ſtated the natural duration of human life, and the circumſtances that tend to prolong our exiſtence beyond the ordinary period. We ſhall not here enter again on any of theſe topics, except to give a more ample account of the gradual approaches of natural death, and ſhall then enumerate the cauſes which uſually produce *violent* or *accidental* death, and mention the opinions of ſome of the beſt writers on the *nature* of death.

367 Gradual approach of natural death.

Natural death is, in the preſent ſtate of civilized ſociety, by no means a common occurrence. When it does take place, its approach is ſlow and gradual. He whoſe life terminates in conſequence of advanced age, (to uſe the language of a celebrated French phyſiologiſt), dies in detail. His external functions ſucceſſively ceaſe to exert their action; all his ſenſes are ſucceſſively loſt, or the ordinary cauſes of ſenſation paſs over them without leaving their uſual impreſſions. The *ſight* becomes obſcure, and at length the humours of the eye no longer tranſmit the rays of light; the *ear* receives only confuſed ſounds, and frequently before death, is altogether inſenſible; the ſenſe of *touch*, in conſequence of the hardneſs and callouſneſs of the cuticle, and the obliteration of many of the ſubcutaneous veſſels, grows dull and uncertain; and all the parts depending on the ſkin ſhow marks of weakneſs; the hair and the beard grow white, and a greater or leſs degree of baldneſs takes place; odours are no longer perceived, or they are perceived but faintly. The taſte uſually ſurvives the reſt of the ſenſes; but that too, at laſt, grows equally obſcure. The functions of the brain partake of the imbecility of the external ſenſes. The imagination in particular becomes dull and often depraved; the memory no longer retains thoſe occurrences which are every day taking place, though it recalls with increaſed reliſh and delight thoſe of paſt times; the judgement becomes weak and wavering.

From the univerſal agency exerted by the nervous ſyſtem on all the animal functions, we muſt expect that when the former is impaired, the latter will be proportionally enfeebled. The faculties of locomotion and of ſpeech are commonly the firſt of theſe that fail; the body totters at every ſtep, the voice grows weak, and the tongue faulters. The motion of the limbs is difficult and painful, and hence is but ſeldom willingly exerted. Not ſo with the vocal organs, though the impediments to utterance are evident and painful to his hearers, the old man himſelf ſeems ſcarcely to attend to them, but talks with proverbial garulity, and eſpecially delights in recounting the ſcenes and actions of his youth.

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While the external functions, and thoſe of the brain, are thus gradually impaired; the internal, or what are commonly called the vital and natural functions, as digeſtion, abſorption, circulation, reſpiration, and ſecretion, proceed with but little derangement. The circulation and reſpiration are indeed ſlower than before, and the appetite is in general leſs keen and returns leſs frequently; but the digeſtive powers of the gaſtric fluids remain in full vigour; and even after death has taken place, are exerted on the coats of the ſtomach; abſorption is alſo very active, and nutrition, at leaſt in many parts of the body, is ſufficiently evident. At length, however, all theſe functions loſe their powers; digeſtion languiſhes; the ſecretions no longer take place; the circulation, eſpecially in the minute veſſels, becomes obſcure, and being deprived of the tonic powers by which it was carried on, gradually ceaſes altogether; the heart no longer propells the blood from its ventricles; and the circulation through the lungs being thus arreſted, theſe organs ceaſe to take in air, make their laſt expiration, and thus the natural life of man is terminated *.

* See *Bichat Recherches Phyſiol.* part i. art. 10.

368 Accidental or violent death.

Accidental death takes place in one of the two following ways; either ſuddenly, in conſequence of ſome great diſturbance produced in the animal economy, as when a man is cut off by a ſudden ſtroke of apoplexy, violent hæmorrhage, *aſphyxia*, &c. or by ſlow and gradual ſteps, in conſequence of ſome leſs violent but ſtill fatal diſeaſe. In the former caſe, it is *ſudden* or *violent* death; in the latter *lingering* death.

Violent death may take place firſt, either in the *brain*, the *lungs*, or the *heart*; but when the action of one of theſe organs ceaſes, that of the others ſoon terminates. The entire ceſſation of life ſeems, however, to be more ſudden in the two latter caſes, and moſt of all in the laſt; when the *heart* is wounded or ruptured, the animal dies inſtantly; when the lungs are rendered inactive in conſequence of ſuffocation, the animal may live for ſeveral minutes, or for an hour or two; but when the *brain* is overwhelmed, he may ſurvive for hours or even days. Thus it ſometimes happens, in caſes of apoplexy, that the patient lies motionleſs, ſpeechleſs, and quite inſenſible to external ſtimuli, while the circulation and reſpiration continue, impeded indeed, but not deſtroyed, for a conſiderable time, though life, as appears from the event, be in a ſtate of irrecoverable declenſion. We ſhall preſently ſhow how theſe circumſtances have been explained.

The uſual ſigns of approaching death are, a very quick and ſmall pulſe, ſcarcely diſtinguiſhable, and commonly intermitting; coldneſs, and generally clammy ſweats about the extremities; a "lack luſtre" eye, ſunk in features, want of expreſſion about the countenance, and a prominence of the bones of the face, with a correſponding hollowneſs in the cheeks, orbits, and eſpecially

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especially at the temples. These last appearances constitute the marks of what has been called *facies Hippocratica*. They are all signs of a loss of activity and power in the circulating and nervous systems. Under these bodily circumstances, the powers of the mind seem to decline, generally with an equal pace with those of the body; and when the medium through which the activity of the soul is manifested can no longer act, we cannot expect to find any further traces even of its existence. Yet at the period of its separation, we are told of brilliant mental exertions of powers of intellect, not equalled in the best portion of existence. It has not been our fortune to see such intellectual animation. At the moment of death, anxiety for those we have loved will sometimes occasion apparently disproportioned exertions; and as they were unexpected, they have been exaggerated. But in no instance could we ever detect the activity of mind independent of the body. To this temporary prison the soul is confined, till, by the destruction of the machine, its animating principle is emancipated, soaring probably in higher, and, we trust, in more blissful, regions *.

369 Signs of approaching death.

* New Lond. Med. Dict. vol. i. p. 534.

370 Signs or criterion of actual death.

A few cases have occurred, in which persons, who were thought dead, have recovered from what was really a state of *suspended animation*; and there is reason to believe, that some unhappy beings have been buried while in this seemingly lifeless state. It becomes, therefore, a matter of the highest importance to ascertain, with certainty, whether or not death has actually taken place. The ordinary signs of death, as enumerated by one of the latest writers on this subject, are as follow:

1. The *suspension of respiration*. 2. The *rigidity* of the limbs. 3. The *loss of sensation* and *motion*. 4. The *want of pulsation* in the heart and arteries. 5. The *spontaneous discharge of feces*. 6. The *collapse*, *opacity*, and *want of lustre* in the *eyes*. 7. The *coldness* of the body. 8. The *paleness* or *lividity* of the countenance. 9. The *relaxation* of the lower *jaw*. 10. The *regurgitation of liquids* to the mouth. 11. The *insensibility* of the *pituitary membrane* of the *nose*. 12. The *collapse*, *softness*, and *wrinkling* of the *lips*. 13. The *hollowness* of the *temples*, and *thinness* and *contraction* of the *nose*. 14. *Putrefaction* ‡.

‡ Davis Reglement concernant les décès, part ii.

Most of these signs singly have been shown to be fallacious; and none of them, except the last, are to be depended on with implicit confidence. Dr Davis recommends the following mode of procedure. "As soon as the evident signs of life cease, let us place the body in a warm or dry bed, give a proper temperature to the air of the apartment, and employ every means for restoring it to life. If we judge, from the nature of the disease which preceded the death, that these means are useless, we may content ourselves with keeping the body, until its decomposition become manifest; but let us never abandon an unfortunate person, who, perhaps, by perseverance in the proper means, may be restored to life: should he recover, he will be a living monument of unexpected resurrection, and of the unceasing efforts of humanity. If a person die of malignant fever, scurvy, internal inflammation, or any other disease which corrupts the fluids, soon after death the belly becomes black and swelled; black or livid spots appear on the limbs and back, the eyes become hollow and soft, and discharge a puriform fluid; the eyelids grow yellow; the mouth opens, because the lower jaw is relaxed; the skin gets soft, the muscles flaccid; and, lastly, the whole body exhales a putrid odour. All these phenomena united, constitute an infallible proof of real death *(N)." * Ibid.

The changes which the animal body undergoes in consequence of death, and during putrefaction, have been amply detailed and explained under CHEMISTRY, chap. xix. sect. 2.

371 Comparative pertinacity of life.

In treating of the general phenomena of life in the first chapter of this article, we made a few observations on the degree of vitality that appears in various tribes of organized beings. There is scarcely a more curious part of the physiology of death than the consideration of the greater or less difficulty with which it is produced in different animals. Some, as the herring and the whiting, die almost instantly on being removed from the situation in which they usually live. Some are killed by a slight blow on the nose or the neck; this is the case with the seal, the rat, the hare, and the rabbit. Others again retain life with great pertinacity. Among the mammalia, the cat is proverbial for being difficult to kill; the sloth has been known to live for above 40 days clinging to a pole, and entirely without food; and Dr Sparrman assures us, that the ratel, or honey weazle (*viverra mellivora*), is so hardy that it is almost impossible to kill it; the colonists and Hottentots both assert, says he, that it is almost impossible to kill this creature, without giving it a great number of violent blows on the nose; and it is remarkable that such a number of hounds as are able collectively to tear in pieces a lion of moderate size, are sometimes obliged to leave the ratel only apparently dead †. Some fishes live for a long time after being removed from the water, and even after being gutted and cut in pieces, as the *carp*, the *flounder*, and the *eel*. It is among the reptiles, mollusca, and zoophytes, however, that we find the most remarkable instances of pertinacity of life. Referring the reader to the article ERPETOLOGY for these instances in reptiles, and to HELMINTHOLOGY for those in zoophytes, we shall here only mention two among mollusca. The sea marigold (*actinia calendula*) is destroyed with such difficulty, that after drilling the holes of the rock from which they appear, with an iron instrument, they have been known to rise again in the same places, and become as numerous as before in the course of a few weeks ‡. Snails whose remarkable suspended animation we have already recorded, may be crushed beneath the foot, and will yet survive, and repair the breaches in their shelly covering; nay, they are capable of passing the ordeal of boiling water, as we learn from the relation of a lady who, wanting some snail shells for a piece of grotto work, attempted to kill the animals by repeatedly pouring over them boiling water; but to her horror and astonishment, she observed them next day crawling about the edges of the vessel in

† Sparrman's Voyage.

‡ Hughes's Nat. Hist. of Barbadoes.

(N) The work of M. Bruhier, *sur l'Incertitude des Signes de la Mort*, from which these remarks of Dr Davis appear chiefly to be taken, created so much alarm in France, that every body dreaded being buried alive. To combat these terrors, M. Louis, in 1752 published his *Lettres sur la Certitude des Signes de la Mort*; in which he has very happily, and we think successfully, refuted the arguments of Bruhier, and has thereby relieved th minds of his readers from one of the most dreadful apprehensions that can appal us on this side the grave.

Of Death. in which she had scalded them *. It is in vain for us to attempt any explanation of these extraordinary phenomena. We must refer them to some principle in the animal economy which is at present unknown.

* *Annual Register*, vol xvii. p. 86.

372 Causes of death.

The remote causes of death have been, by Dr Ontyd, arranged under 12 general heads, to which he gives the name of *classes*. These we shall enumerate, with their principal subdivisions.

I. Death arising from the mechanism of the body.

II. Death from the passions of the mind.

1. *Exciting passions*; 2. *Depressing passions*.

III. Death from superabundance or deficiency of heat.

1. *From superabundant heat*; 2. *From deficient heat*.

IV. Death from electricity.

V. Death from noxious gases.

1. *From hyperoxygenized gases*; 2. *From deoxygenized gases*; 3. *From peculiarly stimulating gases*.

VI. Death from poisons.

1. *Animal poisons*; 2. *Vegetable poisons*; 3. *Mineral poisons*.

VII. Death from universal disease.

1. *Fevers*; 2. *Febrile diseases* (exanthemata).

These seven classes are supposed to produce death by the immediate extinction of the *vital principle*; the five following are supposed to effect this by suppressing the action of some vital organ, or by disordering the chain of the vital powers by destroying the action of some of the intermediate links.

VIII. Death from inflammations.

1. *Inflammations of the head*; 2. *Of the breast*; 3. *Of the belly*.

IX. Death from fluxes.

1. *Alvine fluxes*; 2. *Hemorrhages*.

X. Death from cachexies.

1. *Ulcers*; 2. *Atrophies*; 3. *Debilities and Privations*.

XI. Death from diseases of the nervous system.

1. *Atony*; 2. *Spasm*.

XII. Death from diseases of the secretory organs.

1. *From altered action*; 2. *From altered structure* *.

* *Ontyd on Mortal Diseases*.

373 How these operate.

The manner in which these causes operate in terminating life, is thus stated by the same author.

The causes of the *first class* act by inducing too great a rigidity of the solids, and by rendering them insensible to *stimuli*; the necessary effects of the continued action of the powers of *life*. In death from causes of the *second class*, the person dies in consequence of *apoplexy*, *syncope*, or *suffocation*, the brain, the heart, or the lungs being overwhelmed by accumulated blood. The causes of the *third class* act in a similar manner with those of the second; that of the *fourth* by suddenly extinguishing the *vital principle*; those of the *fifth* always act by inducing *suffocation*. The causes of the *sixth* class act in *four* ways: 1. By abolishing the vital principle by the violence of their stimulus; 2. By destroying the action of the brain, the heart, or the lungs; 3. By producing mortification of the intestinal canal; 4. By secretly and insensibly destroying life. Those of the *seventh* class act in *six* ways: 1. and 2. As in the last; 3. By local inflammation; 4. By *mortification* of some *vital organ*; 5. By a change in the organic structure of the intestinal canal inducing a colliquative *diarrhœa*; 6. By *colliquative sweats* wasting the body.

The causes of the *eighth* class act in *four* ways: 1. By inducing violent convulsions; 2. As in the two last; 3. By suppressing the action of some vital function from the violence of the inflammation; 4. By mortification. The *ninth* class may act in *five* modes: 1. By *spasm*; 2. By fatal *syncope*; 3. By impeded action of some vital organ; 4. By mortification or *sphacelus*; 5. By wasting the strength in *fruitless exertions*. The *tenth* class may act in no less than *nine* ways: 1. By the consumption of some vital organ, or destroying the tone of the whole body; 2. By the violence of the noxious stimulus; 3. By suffocation; 4. By apoplexy; 5. By *syncope*; 6. By hemorrhage; 7. By colliquative *diarrhœa*; 8. By mortification of some organ; 9. By malignant fever from absorbed ichorous matter. The causes of the *eleventh* class act only in two ways: 1. By violent spasm; 2. By apoplexy. Those of the *twelfth* class, produce death in three modes: 1. By the slow effects of the noxious stimulus; 2. By the continually stimulating noxious power alone, or by this and the continual wasting of the blood, to form some peculiar secretion; 3. By impeding or destroying the function of a vital organ *.

* *Ontyd*, p. 637.

Many of these modes of operation are very ill defined, and they may all be reduced to about eight or ten, or perhaps even fewer.

Death has been defined *the separation of the soul from the body* †: the *extinction of the vital principle*; the *extinction of the faculty of answering a stimulus* ‡, &c. &c. Perhaps we cannot describe it better than by calling it *the irrecoverable cessation of all the bodily functions*. By this character we distinguish it from *suspended* animation and *lethargy*, in which *some* of the functions continue; while we acknowledge the survival of the *immaterial part* of our frame. 374 Nature of death.

† *Johnson*.
‡ *Ontyd*.

It has been the general opinion among philosophers, both of ancient and modern times, that death produces only a change of the elements or principles of the organized body; and does not effect the *annihilation* of any part. Modern chemistry has fully confirmed this opinion, and has shown that by putrefaction the body is dissolved into a few *earthy*, *saline*, and *gaseous* products, all capable of entering into new combinations, and thus constituting a part of future bodies. See CHEMISTRY, N° 2572, and MAN, N° 44.

Of all the writers on the nature and phenomena of death, with whom we are acquainted, none has treated the subject with such accuracy and philosophic method, as Bichat. With a summary of some of the leading principles of this able physiologist we shall close the present chapter, and thus terminate our physiological enquiries.

We have already mentioned Bichat's division of life into *animal* and *organic*: see N° 49. Proceeding on the principle of this division, he conceives that the two lives terminate in different ways, and that one often terminates while the other remains active. In the natural death that happens from old age, the *animal life* gradually ceases in the order we have described, N° 367, while the *organic* life remains. The same happens in those cases of violent death where life first ceases in the brain, this organ being the centre of animal life. In other cases of violent or accidental death, the *organic* life first ceases in its central organs, the *heart* or the *lungs*; but in these cases, the *animal* life also is speedily suppressed. 375 Opinions of Bichat.

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TABLE

OF THE MOST IMPORTANT CIRCUMSTANCES

RESPECTING THE

ORGANIC FUNCTIONS

OF THE

HUMAN BODY.

	I. SENSATION.	II. MOTION.	III. DIGESTION.	IV. ABSORPTION.	V. CIRCULATION.	VI. RESPIRATION.	VII. SECRETION.	VIII. REPRODUCTION.
1. ORGANS.	*Cerebrum*, *Cerebellum*, *Medulla Oblongata*, Spinal marrow, Nerves, Organs of Senſe.	Muſcles, Tendons, Bones, Cartilages, Ligaments, and Mucous bags.	Salivary glands, Mouth, Teeth, Gullet, Stomach and Inteſtines, Liver, Pancreas, and Spleen.	Lacteals, Lymphatics, Thoracic duct, Meſenteric glands, Lymphatic glands, Skin.	Heart, Arteries, Veins, and Exhalants.	Noſtrils, *Larynx*, Windpipe, Lungs, and *Diaphragm*.	Salivary glands, Liver, *Pancreas*, Kidneys, *Teſtes*, Mucous glands, Membranes, &c. Miliary glands, Brain?	*Penis*, Teſticles, *Veſiculæ Seminales*, Proſtate gland, Spermatic veſſels in Man; *Vulva*, *Vagina*, *Uterus*, and the *Mammæ*, in Woman.
2. FLUIDS.	Lymphatic and Gelatinous fluids, Nervous fluid?	Gelatinous fluid, *Synovia*, Marrow, Lymph, and Blood.	*Saliva*, Gaſtric juice, Pancreatic juice, Bile, *Mucus*.	Chyle, Lymph, Serous fluid.	Blood, Lymph, and various exhaled and ſecreted fluids.	Blood and *Mucus*.	Tears, *Mucus*, *Saliva*, Gaſtric juice, Pancreatic juice, Bile, Lymph, *Synovia*, Fat, Marrow, *Cerumen*, *Semen*, Urine, Milk, Nervous fluid?	*Semen*, Mucous fluid, Proſtatic fluid, *Liquor amnii*, and Milk.
3. PHENOMENA.	Senſation, Action of external bodies on Man, and Perception of theſe Actions.	Contraction, Dilatation, Loco-motion, Progreſſion. Action of Man on external objects.	Maſtication, Deglutition, Digeſtion in the ſtomach and inteſtines. Mutual Action of Alimentary ſubſtances and the Digeſtive organs.	Imbibition, Action of the Lymphatic veſſels and glands on the fluids, Separation of noxious or uſeleſs matters, and Selection of uſeful ſubſtances.	Contraction, Dilatation, Pulſation, Exhalation, Nutrition.—Mutual action between the Blood and Circulating fluids.	Purification of the fluids, Renewal of action, Animal heat, Mutual action between the air and the animal ſolids and fluids.	Separation of fluids uſeful in the economy, and Expulſion of noxious or uſeleſs parts.	Copulation, Conception, Parturition, Lactation.
4. POWERS.	Senſibility and Vital reſiſtance.	Irritability, Contractility, and Vital reſiſtance.	Diſſolution, Aſſimilation, and Vital reſiſtance.	Irritability, Contractility, Aſſimilation, and Vital reſiſtance.	Elaſticity, Irritability, Contractility, Dilatability, and Vital reſiſtance.	As in Circulation.	Various.	Generative power.
5. RELATIVE PREDOMINANCE.	Moſt predominant in *infancy; female ſex; melancholic temperament; hypochondriac, hyſteric*, and other nervous affections, and in warm climates.	In *manhood;* in the *male* ſex; the *ſanguine* temperament, and in *mountainous* countries.	In *infancy;* in the *female* ſex; in the *ſanguine* temperament; in cold weather and cold climates.	In *childhood;* in the *ſanguine* temperament; in *warm* climates; and during *ſleep*.	In *childhood;* in the *female* ſex; in the *ſanguine* temperament; in warm countries; and in *febrile* and *inflammatory* affections.	Much as in Circulation.	In middle age; various as to ſex and temperament; in *warm* climates.	In *youth;* in thoſe of a ſanguine temperament, and lively imagination.
6. PRINCIPAL MORBID AFFECTIONS.	*Vertigo*, *Coma*, *Delirium*, Inſanity.—Pain, Itching, Want of feeling; *Ageuſtia; Tinnitus aurium*, Deafneſs; Intolerance of light, *Dyſopia; Caligo*, *Amauroſis*.	Spaſm, Convulſion, Twitching, *Paralyſis*.	*Bulimia*, *Pica*, *Nauſea*, *Flatus*, Eructation, Rumination, Vomiting, Heartburn, *Pyrexia*, *Anorexia*.	Glandular obſtruction, Atony of lymphatics.	General fever, Palpitation, *Plethora*, Inanition, Debility, *Syncope*.	Yawning, Sighing, Sobbing, Hiccup, Sneezing, Coughing, Anxiety, *Dyſpnœa*, *Stertor*, *Aſphyxia*, Dumbneſs.	Increaſed ſecretion, Diminiſhed ſecretion, Depraved ſecretion, Jaundice, *Calculus*, &c.	*Priapiſmus*, *Satyriaſis*, *Nymphomania*, *Menorrhagia*, *Amenorrhœa*, Impotence, Sterility.

	I. SENSATION.	II. MOT	REPRODUCTION.
1. ORGANS.	*Cerebrum, Cerebellum, Medulla Oblongata*, Spinal marrow, Nerves, Organs of Senſe.	Muſcles, Tend Cartilages, Li Mucous bags	, Teſticles, *Veſiculæ* *minales*, Proſtate gland, rmatic veſſels in Man; *lva, Vagina, Uterus*, and *Mammæ*, in Woman.
2. FLUIDS.	Lymphatic and Gelatinous fluids, Nervous fluid?	Gelatinous flui Marrow, L Blood.	, Mucous fluid, Proſta- fluid, *Liquor amnii*, and ilk.
3. PHENOMENA.	Senſation, Action of external bodies on Man, and Perception of theſe Actions.	Contraction, Di co-motion, Action of M nal objects.	lation, Conception, Par- rition, L[illegible]ation.
4. POWERS.	Senſibility and Vital reſiſtance.	Irritability, Con Vital reſiſtanc	trative power.
5. RELATIVE PREDOMINANCE.	Moſt predominant in *infancy; female ſex; melancholic temperament; hypochondriac, hysteric*, and other nervous affections, and in warm climates.	In *manhood;* ſex; the *ſan* rament, and *ous* countries.	*outh;* in thoſe of a ſan- *guine* temperament, and vely imagination.
6. PRINCIPAL MORBID AFFECTIONS.	*Vertigo, Coma, Delirium*, Inſanity.—Pain, Itching, Want of feeling; *Ageuſtia; Tinnitus aurium*, Deafneſs; Intolerance of light, *Dyſopia; Caligo, Amauroſis*.	Spaſm, Convulſi ing, *Paralyſi*	*piſmus, Satyriaſis, Nym- omania, Menorrhagia, menorrhœa*, Impotence, terility.

Of Death.

It is to violent or accidental death that Bichat principally confines his discussions, and in order to determine with precision the phenomena that take place in the three species, he examines at great length the relations that subsist among the three functions of circulation, respiration and sensation, as they are affected by the death of the *heart*, the *lungs*, or the *brain*. He first considers those cases of sudden death that commence with the death of the heart; then those originating in the lungs; and lastly those originating in the brain. He shows how, one of these functions ceasing, the others successively stop; he points out the mechanism by which the death of all the parts follows that of the organ first affected; and he determines, according to his own principles, the nature of the several diseases by which the life of the heart, the lungs, or the brain, is extinguished *.

* *Recherches*, part ii. art. 1.

We consider this as the most interesting part of his valuable work, and it well deserves the attentive perusal of every medical man. We regret that we cannot do more than extract from it the view given by the author of the successive phenomena produced by the influence which the death of each of the vital organs exerts on the general death of the body.

476 Progress of death commencing in the heart.

Whenever the heart ceases to act, says Bichat, general death comes on in the following manner. The action of the brain ceases for want of excitation; and from the same defect, the sensation, locomotion and speech, which immediately depend on the general sensorium, are interrupted. Besides, for want of the excitation of part of the blood, the organs of these functions would cease to act, even though the brain were supposed capable of exerting on them its usual influence. The whole of the animal life, then, is suddenly arrested. The man, from the moment that his heart dies, ceases to exist with respect to surrounding objects.

The interruption of *organic* life, which has commenced through the circulation, operates at the same time through the respiration. The mechanical actions of the lungs no longer proceed when the brain ceases to act, since on this organ depends the action of the diaphragm and intercostal muscles. The chemical changes can no longer take place, when the heart can neither receive nor convey the materials necessary for their developement. In short, general death continues to proceed in a gradual manner, by the interruption of *secretion*, *exhalation*, and *nutrition*. These are the effects produced when death is the consequence of a wound of the heart or large blood-vessels, a rupture of the heart, or similar accidents †.

† *Id.* art. 5.

377 Progress of death commencing in the lungs.

The series of phenomena that take place in death, as commencing in the lungs, is different according as the *mechanical* or the chemical action of these organs is first arrested. I. In the former case, as when death is produced by an extensive wound or laceration of the diaphragm, by the fracture of a great many ribs at the same time, &c. they proceed as follows: 1. Cessation of the mechanical action; 2. Cessation of the chemical phenomena, for want of the air which supported them; 3. Cessation of the brain's action for want of the red blood by which it was excited; 4. Interruption of animal life, of sensation, locomotion, and speech, from the loss of the exciting powers of the brain and the red blood on the organs of those functions; 5. Stoppage of the *general* circulation; 6. Stoppage of the circulation in the capillaries, of secretion, absorption, exhalation, for want of the excitation exerted on their organs by the red blood; 7. Cessation of digestion, for want of secretion, and of excitation of the digestive organs. II. When the chemical action of the lungs is interrupted, as when an animal is confined in a *vacuum*; in cases of *strangulation*, *suffocation*, *drowning*, &c. the phenomena of death proceed in the following order: 1. Interruption of the chemical phenomena; 2. Consequent suspension of action in the brain; 3. Cessation of sensation, voluntary motion, voice, and the mechanical functions of respiration; 4. Stoppage of the heart's action, and of the general circulation; 5. Termination of the capillary circulation, of secretion, exhalation, absorption, and, by consequence, of digestion; 6. Cessation of animal heat, which, being the result of all the functions, must cease when all these are terminated ‡.

‡ *Id.* art. 9.

378 Progress of death commencing in the brain.

The phenomena of general death commencing in the brain come on in the following series: 1. Cessation of the brain's action; 2. Sudden interruption of sensation and voluntary motion; 3. Simultaneous paralysis of the diaphragm, and intercostal muscles; 4. Interruption of the mechanical phenomena of respiration, and, by consequence of voice; 5. Cessation of the chemical phenomena; 6. Passage of the *black* blood into the system of *red* blood; 7. Impeded circulation, from the action of the black blood on the heart and arteries, and from the immobility of all the parts, especially the organs of the chest; 8. Death of the heart, and stoppage of the general circulation; 9. Simultaneous interruption of organic life, especially in the parts that are usually penetrated by red blood; 10. Abolition of animal heat §.

§ *Id.* art. 13.

379 Conclusion.

We have now gone through the series of physiological enquiries, into which we proposed to enter in this article. In forming an estimate of the merit due to our labours, we request that our readers will consider the article as in a great measure supplemental to many that have preceded it in the course of the present work. It has been our principal object to fill up blanks and supply deficiencies, especially with respect to *Comparative Physiology*; and to form, with those preceding articles which have a reference to the *animal economy*, particularly ANATOMY, MEDICINE, MIDWIFERY, CHEMISTRY, MAN, one *connected*, if not *uniform* whole. The difficulty of the task we had undertaken will probably be admitted as some apology for the imperfect execution of it; while the variety and interesting nature of the subjects which we have treated, with the numerous references to the most respectable sources of information, will, we trust, render this article acceptable both to the general and the scientific reader.

EXPLANATION OF PLATE CCCCXVIII.

Fig. 1. *Exhibits a view of the exit from the head, and distribution in the chest, of the great sympathetic nerve, intended to illustrate the mutual relations between the head and the principal organs of the chest and belly.*

A. The right *parotid gland* laid bare.

B. The *submaxillary gland.*

C, D, E. The *digastric muscle*, partly covered by the *submaxillary gland.*

Fi

F. Part of the *thyroid gland.*

G, G. The *œsophagus* or gullet.

H, H. The wind-pipe or *trachea.*

II. III. IV. V. VI. VII. The bodies of the fix lower *vertebræ* of the neck; VIII. IX. the two firft vertebræ of the back.

I, K, L. The heart, with part of the pericardium attached.

p, p. The arch of the aorta, drawn afide.

q. The common trunk of the right fubclavian (*n*) and right carotid (*r*) arteries.

P. The *vena cava* from the *fuperior* parts; Q. That from below.

R, S, T. The right lobe of the lungs.

U, V. Part of the left lobe.

W, X, Z. Mufcular parts of the *diaphragm.*

a. The firft cervical or great *ganglion*, from which proceed, *b.* The trunk of the great fympathetic nerve, and *c.* The eighth pair of nerves, or *par vagum.*

d. The lower cervical *ganglion*, oppofite the fifth cervical *vertebra.*

e. The upper thoracic *ganglion*, oppofite the firft vertebra of the back.

f. The third dorfal *ganglion*, between the fecond and third rib.

g. The *acceffory nerve* of Willis.

h, i, k, l. Trunks of fome of the cervical nerves.

m. The *cardiac plexus* formed by branches from the fympathetic nerve.

n, n. The *par vagum* running down to the *diaphragm*, through which it paffes, unites with the *intercoftal*, forms various *ganglia*, and gives branches to moft of the abdominal *vifcera.*

o, o. The *phrenic* nerves diftributed to the *diaphragm.*

Fig. 2. A fection of the cuticle of the *lilium chalcedonicum*, to fhew the *lymphatic veffels*, much magnified.

Fig. 3. A fimilar magnified view in the *onion.*

Fig. 4. Ditto in the *pink.*

Fig. 5. Reprefents the atlantal extremity of the flow lemur *(lemur tardigradus)*, to fhow the curious divifion of the *fubclavian* artery.

a. The fubclavian artery, lying upon the *fubfcapularis* mufcle.

b. The divifion of the artery into equal-fized cylinders.

c. The ulnar artery proceeding to divide in the ufual manner.

Fig. 6. Reprefents the facral extremities of the fame animal, fhowing a fimilar divifion of the inguinal artery.

a. The *diaphragm.*

b. The defcending *aorta.*

c, c. The iliac *arteries.*

d. The trunk of the *inguinal* artery, fituated among the cylinders.

e. The femoral artery under fimilar circumftances.

The annexed Table fufficiently explains itfelf.

ERRATA.

Page 501. *col.* 2. *line* 23. *from the top*, *for* the circulation, *read*, the leffer circulation. N°. 360. *for* chryfolites, *read*, chryfalids.

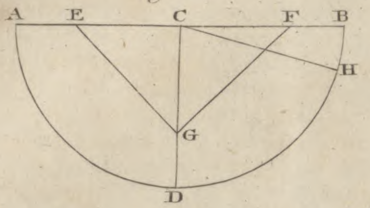
INDEX.

Circulation

P.

PHYTOLACCA,

Fig. 1.



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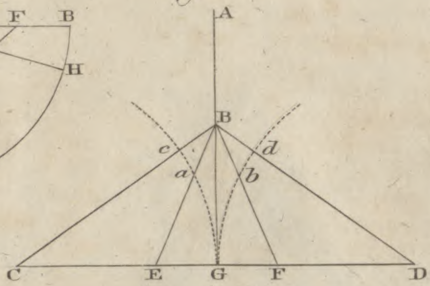

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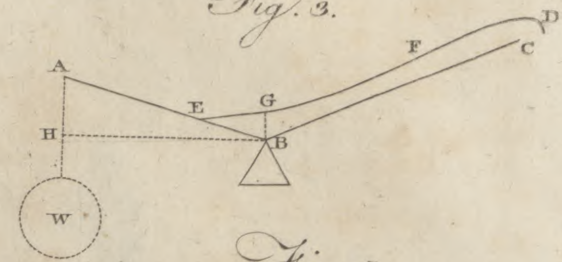

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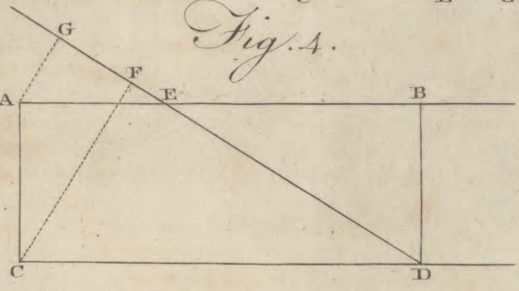

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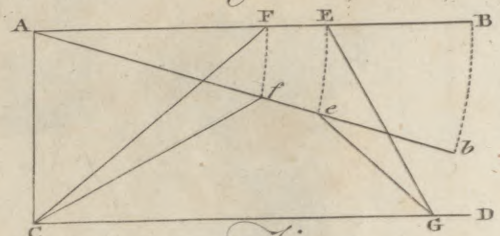

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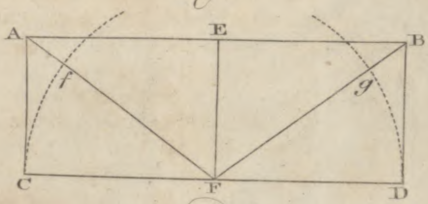

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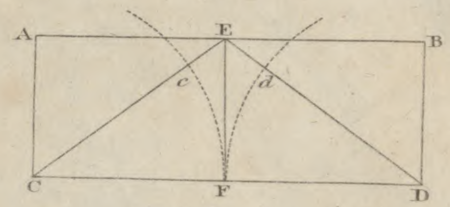

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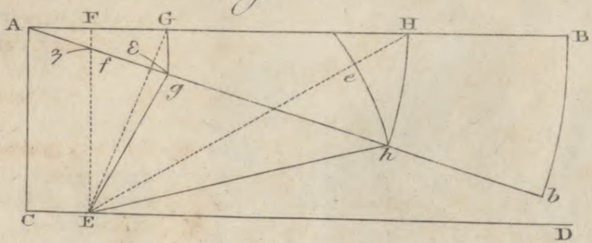


Fig. 9.

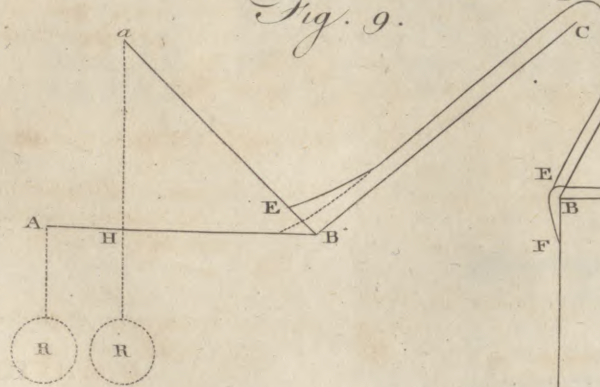


Fig. 10.

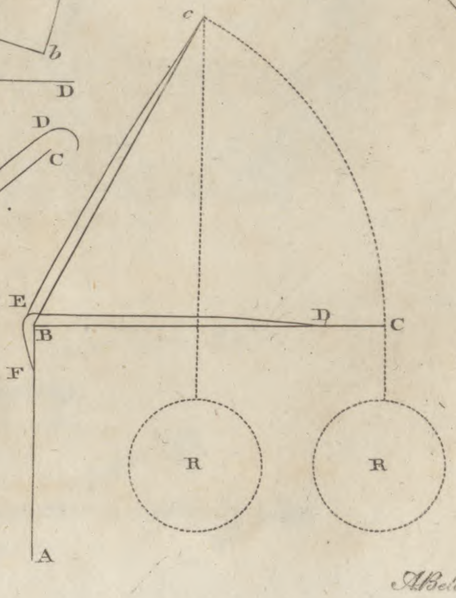
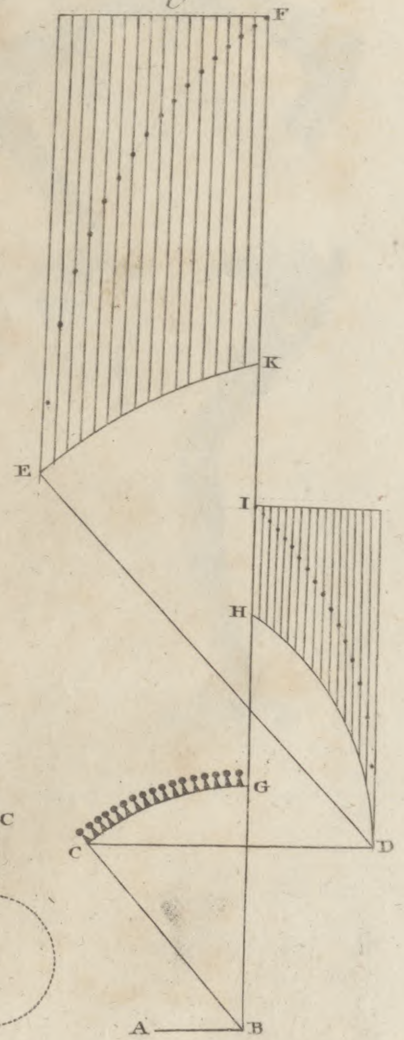


Fig. 11.



A. Bell Prin. Wal. Sculptor fecit.

Fig. 1.

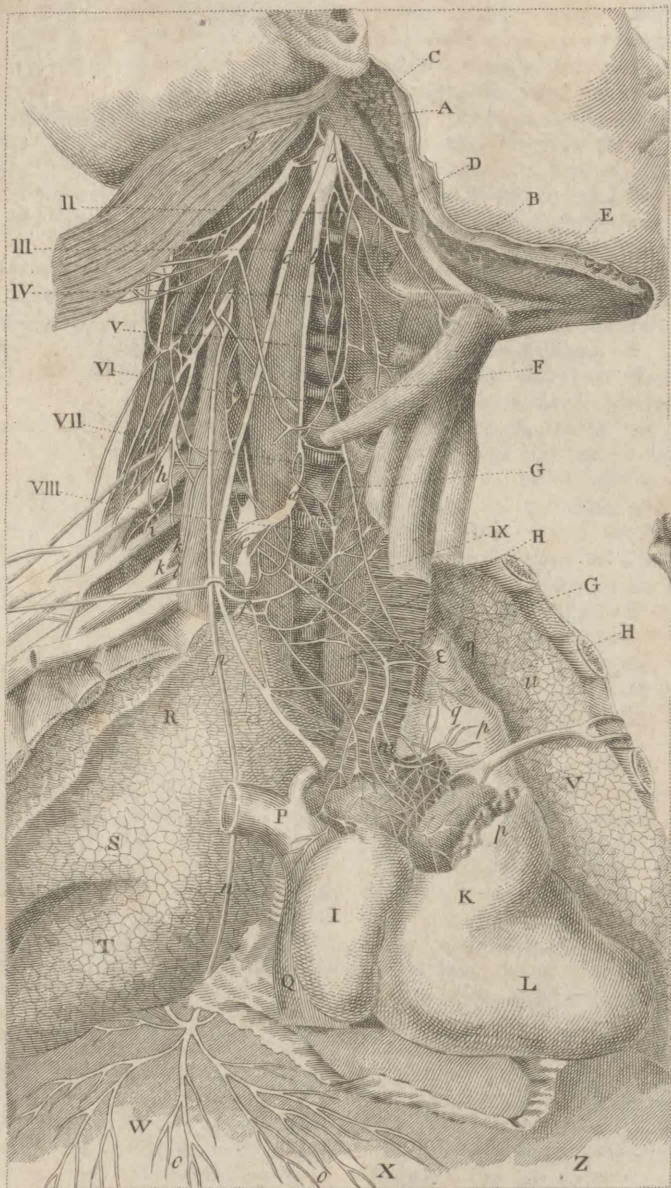
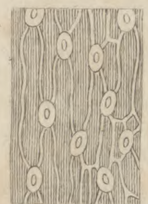


Fig. 2.

Fig. 3.



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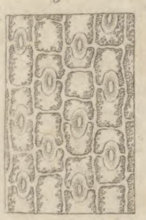

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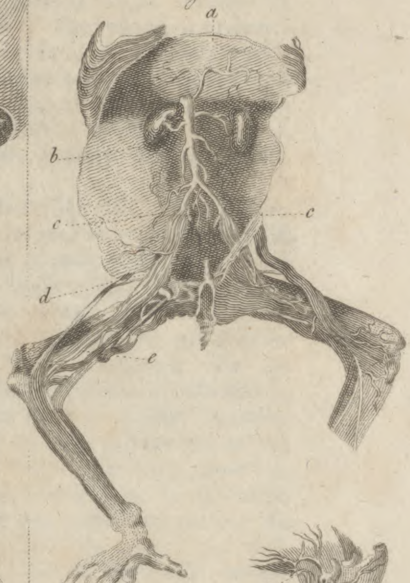
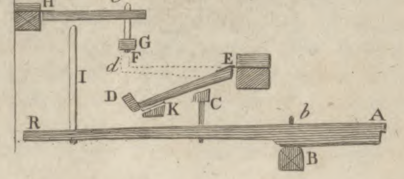


Fig. 5.

PIANO FORTE KEY



A. Bell Prin. Wal. Sculptor fecit.

PHYTOLACCA, Pokeweed, or *American Nightſhade*, a genus of plants belonging to the decandria claſs. See Botany *Index*.

PHYTOLOGY, a diſcourſe concerning the growth, kind, and virtues of plants. See Botany, and Materia Medica.

PHYTON, a general of the people of Rhegium againſt Dionyſius, the tyrant of Sicily. He was taken by the enemy, and tortured, and his ſon was thrown into the ſea. See Syracuse.

PIA mater, a thin membrane which covers the brain and is in immediate contact with it. See Anatomy *Index*.

PIABA, in *Ichthyology*, is a ſmall freſh-water fiſh caught in all the rivers and brooks in the Braſils, and in ſome other parts in America. It is about the ſize of the common minow.

PIABUCU, in *Ichthyology*, is an American fiſh, eaten in many places by the natives. It is ſaid to be ſo ravenous, and greedy of blood, that if a perſon go into the water with a wound in any part of his body, the piabucu will make up to it to ſuck the blood. It ſeldom exceeds four inches in length.

PIACENZA is a city of Italy, in the duchy of Parma, in E. Long. 10. 25. N. Lat. 45. It is a large handſome city, whoſe name is derived by ſome from its pleaſant ſituation, in a fruitful plain, on the Via Æmilia, about half a mile from the Po. It is the ſee of a biſhop ſuffragan of Bologna, and has a univerſity, but of no great fame. It is defended by a wall and a ſtrong citadel, and is reckoned about three miles in circumference, ſo that it is ſomewhat bigger than Parma. The houſes are low, but well built; the great ſtreet called the *Stradone* is in a direct line and of equal breadth, with a foot-way fenced with poſts on each ſide like London, and is about 3000 feet long. The houſes are generally built of brick, and ſome of them are prettily painted. The cathedral is an old ſtructure, but well adorned within. The duke of Parma, who is ſovereign of Piacenza, has a palace in the city built by Vignola. There are many excellent paintings in this place. There are two chapels painted, one with the hiſtory of St Catharine, and the other with a picture of Chriſt, as alſo the altar of the church of St Auguſtin, all by Pordenone. In the ſame church there is a fine picture of the bleſſed virgin, St Peter, and St Paul, by Paolo Veroneſe. At the Capuchins there is a Francis by Guercino. There is a fountain ſaid to have been erected here by Julius Cæſar, and the equeſtrian ſtatues of the famous general Alexander I. duke of Parma and Placentia, and of his ſon Ranuccio, both in the great ſquare. In the palace of Scotti, there are a great many fine pictures by Lanfranco, who had been a page in their family, and among the reſt the rape of Helen, the taking of Troy, the bleſſed virgin, and St Francis. The trade of this city conſiſts chiefly in their cheeſe, as at Parma, theſe cities being ſurrounded with the richeſt paſture grounds in Italy; though the greateſt part of what is called Parmeſan cheeſe is made in the duchy of Milan, and particularly at Lodi. See *Parmeſan Cheese*.—Without the walls, which are waſhed by the rivers Trebbia and Po, there is a large ſeminary or college, magnificently erected by Cardinal Alberoni, a native of this city, but conſiderably hurt by the modern Goths in the laſt war. Towards the north of the city is the mouth of the river Trebbia, famous for the victory which Hannibal obtained over the Romans.

PIANO Forte, or Forte Piano, is a muſical inſtrument, which is too well known to require any detailed deſcription. We ſhall here, however, notice ſome of its peculiarities. The voice, it has been obſerved, is the original muſical inſtrument; of this all other inſtruments are to be conſidered but as imitations; and it is remarkable with what promptitude, as well as accuracy, the voice of man obeys the impulſe of the heart. Even a coarſe ear is hurt by an error in its tone, amounting to what is called a *comma*; and a limited voice can execute melodies which include 12 notes, or an octave and a fifth. Between theſe extremes the motion of the glottis does not amount to one-twelfth of an inch, which muſt therefore be divided by the moſt ordinary finger into more than 1000 parts. All this too, without any ſeeming effort of thought, is done in an inſtant, and repeated with rapidity, without miſtaking one of the diviſions.

The great object in the conſtruction of muſical inſtruments is, to bring them as near as poſſible to expreſs the ſounds produced by the human voice: the violin, however, and a few of the ſimple wind inſtruments, are the only ones found fully to expreſs theſe momentary gradations of ſentiment, and thoſe tender and delicate emotions with which the heart is agitated. For the purpoſe of removing this defect of harmonic inſtruments, the ſwell was added to the organ. Similar improvements were alſo attempted on other inſtruments of the ſame kind, and in the ſame way. The harpſichord was ſhut up like the ſwell organ, and was opened by means of pedals, when the performer wiſhed to enforce the ſound. But as this was found not to ſucceed well, other methods were tried, and in particular uniſons were added to each note, which were brought on, either by means of pedals, or by another ſet of keys; and in this way the power of the harpſichord was greatly improved. Among all the keyed inſtruments, the Engliſh piano forte ſeems to merit the preference, on account of the ſuperior force of tone, adequate ſweetneſs, and great variety of voice, of which, by the ingenuity of Britiſh artiſts, it has now become ſuſceptible. It has been called a national inſtrument, becauſe it is ſaid to be an Engliſh contrivance, the invention of the celebrated poet, Maſon. Mr Maſon had ſeen ſome attempts that were made by the Germans to make keyed dulcimers, which were in ſome meaſure ſuſceptible of the *forte* and *piano*; but as they were all conſtructed on one principle, and required a particular touch of the finger, which was of difficult acquiſition, and which ſpoiled it for harpſichord practice; as they were alſo deficient in delicacy and juſtneſs; and as the performer was by no means certain of producing the very ſtrength of ſound intended, Mr Maſon removed all thoſe imperfections, by detaching the mallet entirely from the key, and giving them only a momentary connection. It is by this improvement that the Engliſh piano forte is diſtinguiſhed from all others. Mr Maſon's general principle may be fully underſtood by the following deſcription. In the figure on Plate CCCCXVIII. the parts are repreſented in their ſtate of inaction. The key ABK turns, as uſual, on the round edge of the bar B, and a pin *b*, driven into the bar, keeps it in its place.

Piano Forte.

The dot F repreſents a ſection of the ſtring. ED is the mallet, having a hinge of vellum, by which it is attached to the upper ſurface of the bar E. At the other end is the head D, of wood, covered with ſome folds of prepared leather. The mallet lies in the poſition repreſented in the figure, its lower end reſting on a cuſhion-bar K, which lies horizontally under the whole row of mallets. The key AR has a pin C, tipt with a bit of the ſofteſt cork or buckſkin. This reaches to within $\frac{1}{20}$th of an inch of the ſhank of the mallet, but muſt not touch it. The diſtance E *e* is about $\frac{1}{3}$d or $\frac{1}{4}$th of the length of the ſhank. When the end A of the key is preſſed down on the ſtuffing (two or three thickneſſes of the moſt elaſtic woollen liſt) it raiſes the mallet, by means of the pin C, to the horizontal poſition E *d*, within $\frac{1}{8}$th or $\frac{1}{10}$th of an inch of the wire F; but it cannot be ſo much preſſed down as to make the mallet touch the wire. At the ſame time that the key raiſes the mallet by means of the pin C, it alſo lifts off the damper G (a bit of ſpunge) from the wire. This damper is fixed on the end of a little wooden pin G *g*, connected with the lever *g* H, which has a vellum hinge at H. This motion of the damper is cauſed by the pin I, which is fixed into the key near to R. Theſe pieces are ſo adjuſted, that the firſt touch of the key lifts the damper, and, immediately after, the pin C acts on the ſhank of the mallet. As it acts ſo near to its centre of motion, it cauſes the head D to move briſkly through a conſiderable arch D *d*. Being made extremely moveable, and very light, it is thus *toſſed* beyond the horizontal poſition E *d*, and it ſtrikes the wire F, which is now at liberty to vibrate up and down, by the previous removal of the damper G. Having made its ſtroke, the mallet falls down again, and reſts on the ſoft ſubſtance on the pin C. It is of eſſential importance that this mallet be extremely light. Were it heavy, it would have ſo much force, after rebounding from the wire, that it would rebound from the pin C, and again ſtrike the wire. For it will be recollected, that the key is, at this time, down, and the pin C raiſed as high as poſſible, ſo that there is very little room for this rebound. Leſſening the momentum of the mallet by making it very light, making the cuſhion on the top of the pin C very ſoft, and great preciſion in the ſhape and figure of all the parts, are the only ſecurities againſt the diſagreeable rattling which theſe rebounds would occaſion. In reſpect to the ſolidity and preciſion of workmanſhip, the Britiſh inſtruments are unrivalled, and vaſt numbers of them have been ſent to all parts of the continent.

As the blow of ſo light a mallet cannot bring much ſound from a wire, it has always been found neceſſary to have two ſtrings for each note. Another circumſtance contributes to enfeeble the ſound. The mechaniſm neceſſary for producing it makes it almoſt impoſſible to give any conſiderable extent to the belly or ſound board of the inſtrument. There is ſeldom any more of it than what occupies the ſpace between the tuning pins and the bridge. This is the more to be regretted, becauſe the baſſes are commonly covered ſtrings, that they may be of a moderate length. The baſs notes are alſo of braſs, which has a conſiderably lower tone than a ſteel wire of the ſame diameter and tenſion. Yet even this ſubſtitution for ſteel in the baſs ſtrings is not enough. The higheſt of them are much too ſlack, and the loweſt ones muſt be loaded, to compenſate for want of length. This greatly diminiſhes the fullneſs, and ſtill more the mellowneſs and diſtinctneſs of the tone, and frequently makes the very loweſt notes hardly appreciable. This inequality of tone about the middle of the inſtrument is ſomewhat diminiſhed by conſtructing the inſtrument with two bridges; one for the ſteel, and the other for the braſs wires. But ſtill the baſs notes are very much inferior to the treble.

Piano Forte, Piaſtus.

PIASTUS, a native of Poland, was originally a wheelwright and the ſon of Coſſiſco, a citizen of Cruſwitz. He flouriſhed in the year 830, when on the extinction of the family of Popiel great diſputes aroſe about his ſucceſſor, and Cracow was afflicted with a ſevere famine. During this extremity, when the people were dropping down in the ſtreets, two angels in human forms, as the ſtory is told, took up their reſidence with Piaſtus, who was celebrated for his piety and extenſive charity. He had nothing left but a ſmall caſk of the common liquor of the country, and this he preſented to his new gueſts, who, charmed with his hoſpitality, promiſed him the crown of Poland. The faith of Piaſtus was equal to his other virtues: he implicitly believed the word of his gueſts, and piouſly followed their directions in every particular. He was ordered to diſtribute the liquor out of his little caſk to the multitude: he did ſo, and found that it was inexhauſtible. The people were aſtoniſhed; all cried out, "A miracle!" and the electors determined to chuſe a perſon in whoſe favour Heaven had ſo viſibly declared: Piaſtus was accordingly taken from his ſhop, and raiſed to the ducal dignity.

Mod. Univ. Hiſtory, vol. xxx. p 336, &c.

Such is the relation of the canon of Cracow, which differs in many particulars from the account given by Guagnini, and ſeveral other hiſtorians. According to them, Piaſtus had prepared a ſmall collation, to entertain ſome friends who were aſſembled at the birth of a child. Two pilgrims, Paul and John, afterwards murdered at Rome, came about this time to Cracow. They begged charity at the door of the election-hall, and were rudely repulſed; upon which they ſtumbled on the houſe of Piaſtus, and were kindly received. The miracle we have mentioned was wrought by them; and the two pilgrims, and not angels, were the inſtruments of the elevation of the hoſpitable wheelwright. Though we pay but little regard to the marvellous means by which Piaſtus aſcended the ducal throne of Poland, it would be preſumptuous entirely to omit a fact atteſted by all the writers upon this ſubject: it was proper, therefore, to take notice of it, and we leave the reſt to the reader's judgement.

Being now raiſed to the ſupreme dignity, he was not intoxicated with his proſperity. His natural charity, benevolence, and ſweetneſs of diſpoſition, remained: nothing was altered but his power of doing good. He was truly called the father of his people: the injured never returned unredreſſed, nor merit unrewarded. Piaſtus wiped the tear from the eyes of the widow; and was himſelf the guardian of the orphan, and the general patron of the poor and diſtreſſed. His excellent inclinations ſerved him in the room of great abilities; and the happineſs that his people enjoyed made them forget that their prince was not born a ſtateſmen and a warrior. Several inteſtine commotions aroſe during his adminiſtration, all which he quelled by the mildneſs and clemency of his nature: his nobility were aſhamed of rebelling againſt a ſovereign who devoted his whole life to render his people happy. He removed the court from Cruſwitz, a city which he deteſted, becauſe it was the ſcene of Popiel's crimes and tragical end, and fixed his reſidence at Gneſna, where he died beloved, eſteemed, and even adored by his ſubjects.

It is in memory of this excellent prince, that all the natives of Poland, who have been ſince promoted to the ducal or regal dignity, were called Piaſtes, in contradiſtinction to the foreigners.

Piaſtus aſſociated his ſon Ziemovitus with him in the government before his death; a circumſtance of much benefit to the people.

PIAZZA, in *Building*, popularly called *piache*, an Italian name for a portico, or covered walk, ſupported by arches.

The word literally ſignifies a broad open place or ſquare; whence it alſo became applied to the walks or porticoes around them.

PIBROCH, ſays Dr Beattie *, is a ſpecies of tune peculiar I think, to the Highlands and Weſtern iſles of Scotland. It is performed on a bagpipe, and differs totally from all other muſic. Its rythm is ſo irregular, and its notes, eſpecially in the quick movement, ſo mixed and huddled together, that a ſtranger finds it almoſt impoſſible to reconcile his ear to it, ſo as to perceive its modulation. Some of theſe pibrochs, being intended to repreſent a battle, begin with a grave motion reſembling a march, then gradually quicken into the onſet; run off with noiſy confuſion and turbulent rapidity, to imitate the conflict and purſuit; then ſwell into a few flouriſhes of triumphant joy; and perhaps cloſe with the wild and ſlow wailings of a funeral proceſſion.

* *Eſſay by Dr Beattie*, 8vo edit. p. 422. note.

PICA. See CORVUS, ORNITHOLOGY *Index*.

PICA Marina. See HÆMATOPUS, and ALCA, ORNITHOLOGY *Index*.

PICA, in *Medicine*, a depravation of appetite, which makes the patient long for what is unfit for food, or incapable of nouriſhing; as chalk, aſhes, coals, plaſter-lime, &c. See MEDICINE *Index*.

PICA, or *pye*, had formerly the ſame ſenſe as *ordinal*, meaning a table or directory, pointing out the order in which the devotional ſervices appointed for different occaſions were to be performed. Accordingly we are told it is derived from πι, a contraction of πιναξ, *a table*; and by others from *litera picata*, a great black letter at the beginning of ſome new order in the prayer. The term was uſed in a ſimilar ſenſe by officers of civil courts, who called their kalendars or alphabetical catalogues directing to the names and things contained in the rolls and records of their courts the *pyes*.

PICA, or *Picus, John*, prince of Mirandola and Concordia, was born in the year 1463, under the pontificate of Pius II. He was the youngeſt ſon of John Francis of Mirandola, and Julia, a lady of the noble family of Boiard. Some of the credulous hiſtorians of the time have related, that at his birth a globe of fire was ſeen to reſt upon his mother's bed, portending, ſay they, by its ſhape the perfection of his genius, and by its element, the celeſtial turn of his mind. As ſoon as he was capable of receiving inſtruction, he was placed by his mother's care under the moſt able maſters, and very early diſtinguiſhed himſelf by the vigour of his application, and the ſtrength of his memory; of which ſuch prodigies are related as would be very difficult to credit, were we not aſſured by ſome modern inſtances, of the perfection to which that faculty may be carried. At the age of fourteen he was ſent by his mother's direction, who was deſirous that he ſhould aſſume the clerical functions, to Bologna, at that time the principal reſort of thoſe who ſtudied the pontifical law. After ſpending two years there, he became diſguſted with this purſuit, although ſuch was his induſtry, even at that early age, that he compiled an epitome of the pontifical epiſtles or decretals. His diſpoſition, however, ſtrongly led him to the purſuit of philoſophy, with an eager curioſity to penetrate the ſecrets of nature and ſcience: with this view he travelled over Italy and France, viſited the moſt celebrated ſchools of each, and ſtudied under the moſt famous teachers of both countries. After ſeven years ſpent in this courſe of inſtruction, and at the age of twenty-three, he went to Rome, and, after the faſhion of the ſcholars of that time, brought himſelf into notice by publicly propoſing literary queſtions for diſputation. This ſort of challenge was very common in that age, and, when printing was ſcarcely practiſed, and the name of a man of learning leſs rapidly extended than it is now, was almoſt the only method that a perſon of ſuperior attainments had to make himſelf known. Mirandola propoſed 900 queſtions, or as they were called *concluſiones*, in dialectics, mathematics, natural philoſophy, and divinity, drawn not only from the ſtores of the Latin and Greek, but from the myſteries of the Hebrews and the arcana of the Chaldæans and Arabians. In addition to the endleſs topics of metaphyſics, theology, and the ordinary ſubjects of diſputation, into which he entered very profoundly, the *concluſiones* involved the ancient and obſcure philoſophy of Pythagoras, Triſmegiſtus, and Orpheus; the doctrines of the Cabala, or myſtic interpretation of the ſacred writings, according to the Hebrews, taught by Origen and Hilarius; the extent, uſes, and learning of natural magic, which was vindicated from the vulgar reproach of impiety and necromancy. Seventy-two new phyſical and metaphyſical dogmata of the author's invention were likewiſe propoſed and defended. Theſe propoſitions, according to the oſtentatious practice on theſe occaſions, were fixed in the moſt public places in Rome, and the propoſer engaged to defray the expences of any one who ſhould come from a diſtance for the purpoſe of diſputing with him. This challenge did not bring forward any diſputants, but expoſed Mirandola to much envy and jealouſy, particularly from the profeſſors of ſcience at Rome, who felt the reflection that would be caſt upon their credit by their declining a competition which they durſt not encounter. Unable to injure his fame as a ſcholar, they made a much more dangerous attack upon the ſoundneſs of his faith; thirteen queſtions were ſelected, which were charged with the terrible ſuſpicion of hereſy and contempt of the ordinances of the church; a ſuſpicion very readily liſtened to by the church when directed againſt great learning, which the increaſing influence of philoſophy and letters began to make her watch with extreme jealouſy. Mirandola repelled this attack by publiſhing his Apologia, or Defence of the accuſed Propoſitions; which if he did not effectually clear away the ſuſpicions he had incurred, tended to confirm his enemies in their dread of his learning and powers; and it muſt be owned that, overlooking

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ing the misapplication of talents to such subjects, the Apologia exhibits a command of profound and well digested learning and keen argument, truly astonishing at the age of twenty-three. This work, and the discussions it contained of certain delicate points, added to some hints of the limit of pontifical controul in matters of faith, were so disagreeable to Pope Innocent VIII. that he interdicted the reading both of the Apology and the disputed questions. The love of glory, however, was not Mirandola's only passion: his youth, splendid accomplishments, and the graces of his person, for which he is said to have been remarkable, attracted the admiration and caresses of many distinguished Roman ladies, who united the love of letters to that of pleasure, a taste very common amongst the Italian ladies of that age. The young philosopher yielded to the force of these allurements, or rather, according to the account of his nephew, and biographer, Francisco of Mirandola, eagerly followed the bent of his disposition, naturally inclined to obey the attractions of beauty.

But this life of pleasure, however suitable to his condition and inclinations, was of a short continuance. Irritated by the restless persecutions of his enemies, and obliged perpetually to defend himself against the imputation of heresy, the most formidable calumny which in that age any man could have to contend with, he detached himself from vicious pleasures, and regulated his manner of life by rigidly observing the laws of abstinence imposed by Christianity; for being a firm adherent to the Christian doctrines, the charge of infidelity and the vigilance of his enemies made him the more solicitous to guard against the appearance of disobeying them. Becoming from this time wholly devoted to learning, he soon acquired such celebrity that the most eminent scholars from all parts of Italy came to visit him for conversation or instruction. As a proof of the sincerity of his reformation, he committed to the flames five books of elegiac poetry which he had composed on the subject of his amours, together with numerous pieces in Tuscan verse, which had been addressed to his various mistresses. There is perhaps reason to lament that the zeal of a new convert would not be satisfied without this sacrifice. It must, however, be considered that the spirit of religion at that period exacted many sacrifices from the professors of Christianity, which the lenient temper of these times does not call for. An example of this severity is to be met with amongst the works that still remain of Mirandola; at the end of which, in the folio edition published by his nephew, we find a learned and entertaining comment, in the Italian language, upon a composition of his friend Girolamo Benivieni, entitled *Una Canzona de Amore secundo la mente et opeuione de' Platonici*, "A poetical treatise upon love, explaining the doctrines of the Platonists." The author, Girolamo, informs the reader, in a short preface, that he had determined to suppress this poem and comment out of regard to his friend's character and his own; deeming it unbecoming a professor of Christianity, in treating of celestial and divine love, "to treat of it as a Platonist and not as a Christian;" but that having lent it to some of his friends for their perusal, an imperfect and erroneous copy was printed, which obliged him, but not till after the death of Mirandola, to publish it correctly; and he takes care to allege, in excuse for himself, that he has apprized the reader of his plan by the title of the poem, and warned him in all places where Plato's opinions depart from those of Christ, that the doctrines of a gentile and a heathen are not entitled to the least weight compared with the reasonings of the Christian theologists, "and particularly the irrefragable arguments of the angelic doctor St Thomas of Aquino."

The first fruit of Mirandola's devotion to sacred literature was the Heptaplus, or Comment upon the Six Days of the first Chapter of Genesis, which was written in 1491. Two years afterwards he published a treatise in ten chapters, *de Ente et Uno;* the object of which was to reconcile the doctrines of Plato and Aristotle, and to demonstrate that the disputes of their respective followers originated in a misconception of the opinions of these philosophers relative to the *Ens* and *Unum*, at that time a subject of mighty strife among the learned. This treatise was held in high esteem by both sides. It was the last work of consequence that the author lived to complete; but he had laid the plan of a vast and comprehensive work, which his early death prevented the execution of. This was no less than to confound the seven enemies of the Christian church, by examining and refuting all their errors. In the prosecution of this design, he had composed and perfected before his death twelve books against astrology, the most popular and the most pernicious superstition which then infested the world. Paulus Jovius, bishop of Nocera, has left a testimony to the merits of this work, which is above all other encomiums:—"In this excellent though unfinished work, Mirandola attacked the astrologers with such erudition and keenness, and so ably exposed the absurdity and vanity of the whole art of divination, that he seems to have deterred the professors of the occult sciences from writing *."

* *Paul. Jov. Elog. Doct. Vir.* p. 92.

This great design, as well as many others which Mirandola had formed, particularly that of a more complete essay towards reconciling the opinions of Plato and Aristotle, was frustrated by his death. From the time that he left Rome, which was soon after the publication of the Apologia, Mirandola generally resided either at Ferrara or at Florence. The friendship of the prince of Ferrara and its vicinity to his paternal seat attracted him to the former place; but Florence was the most agreeable to him, on account of the society of literary men which it afforded, and particularly of *Politian* and *Lorenzo de Medici*, with whom he entertained a close friendship. Besides these two illustrious men, his society was cultivated by other eminent scholars, among whom was the learned and unfortunate Hieronymus Savanarola, and Hermolaus Barbarus: Petrus Crinitus, the pupil of Politian †, mentions him as excelling all his companions in the erudition and eloquence of his conversation. The same author has left us an account of Pica's laborious studies; for when Politian had expressed in his presence high admiration of his great genius and learning, Mirandola with singular modesty answered, that he deserved no praise but for his assiduous application—"Gratulandum potius, intelligite, assiduis vigiliis atque lucubrationibus, quam nostro ingenio plaudendum ‡."

† *P. Crinitus de honesta Discip.* lib. iii. c. 2. lib. v. c. 1. & lib. ii. c. 2.

‡ *Ib.* lib. ii. c. 2.

His library likewise is celebrated by the same writer, and is said by Francisco de Mirandola to have cost 7000 pieces of gold. His accomplishments were not confined to subjects of abstruse literature; in his youth he was much attached to music, in which he acquired such skill, that

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that ſome of his melodies were publicly received, and held in great eſteem. It might alſo be concluded, from an anecdote related by Petrus Crinitus, that he was not unacquainted with phyſic; for according to that author, when Hermolaus Barbarus was ſeized at Rome with a dangerous fever, Mirandola ſent him from Florence a medicine prepared by himſelf. No man ever teſtified a more ſincere devotion for learning and philoſophy, to the contempt of all other qualifications, than the Prince of Mirandola. He poſſeſſed a very large eſtate, which he beſtowed almoſt entirely upon works of charity, except what was ſpent in collecting books, and entertaining and providing for literary men. At length, however, about three years before his death, he made over to his nephew Franciſco his principality and poſſeſſions in Mirandola, and obtained a confirmation of the grant from Maximilian, the Roman emperor, to whom that principality was ſubject. He reſerved to himſelf only enough to purchaſe a ſmall eſtate near Ferrara, where he ſpent the remainder of his life, except when he reſided at Florence, in elegant and learned retirement. His mother, under whoſe care he received his education, had deſtined him for the church; and he was often urged by his friends to embrace the ſacred profeſſion, with the certainty of the higheſt honours and emoluments: but nothing could induce him to quit the life that he had choſen. He died of a fever at Florence, in the year 1494, in the 31ſt year of his age, on the ſame day that Charles IX. of France entered that city on his famous expedition into Italy. That monarch, hearing of Mirandola's illneſs, as he approached the city, ſent two of his own phyſicians to his aſſiſtance; but in ſpite of their aid, the violence of his diſorder put an end to his exiſtence in 13 days.

With reſpect to the works of this author, ſomething has already been ſaid, and little more remains to be obſerved. The *Concluſiones* afford a very complete ſpecimen of the learning of the age, and of what were deemed the moſt valuable purpoſes to which learning could be applied. However uſeleſs and unprofitable theſe purpoſes may appear to us, it will not be denied by any one, who has the curioſity to look through the *Concluſiones*, that the maſs of learning, which muſt have been poſſeſſed by the propoſer of them, is prodigious; when it is recollected that, at the time he propoſed them, he was no more than 23 years of age. For there is not the leaſt reaſon to ſuppoſe, that a perſon whoſe works prove him to have been a man of profound learning, and who, in an age and nation diſtinguiſhed by ſome of the brighteſt ſcholars that ever appeared, was ranked by their own judgement amongſt the firſt, ſhould have challenged the diſcuſſion of any of the propoſed ſubjects, without being well provided with the knowledge neceſſary for ſuch a debate. The manner in which the queſtions were propounded leave little room to doubt that the author was deeply verſed in the reſpective ſubjects of them; and the Apology for the accuſed propoſitions, particularly thoſe *de Salute Origenis* and *de Magiâ atque Cabalâ*, diſcover familiarity with the writings of the Fathers, as well as with the Greek and Hebrew claſſics, and a facility of language and argument that could not be acquired at that age without extraordinary powers of mind. It would be worth while to tranſcribe the whole of this curious piece for the amuſement of ſuch of our readers as may not have acceſs to the original, but our limits do not admit of it.

It is curious to obſerve how greatly the ſudden growth of learning outſtripped that of ſolid ſcience. No age, perhaps, was ever ſo remarkable for the learning which it produced as the period from the middle of the 15th century to the beginning of the 16th; yet, except the ineſtimable obligations we owe to the learned men of that time for their editions of the claſſics, later ages have been little benefited by their works, which are either loſt or neglected, and even the ſciences they treated of exploded and ridiculed. School-divinity and metaphyſics, though the moſt attended to, were not the only ſtudies in which the vaſt erudition of that age was waſted. The myſterious doctrines of the Cabala formed a favourite ſtudy of ſome of the moſt learned ſcholars. The propoſition which laid Pica open to the indignation of the church, was that in which he aſſerted the orthodoxy of Origen; for Origen, notwithſtanding his meritorious labours in the cauſe of Chriſtianity, his daring zeal and ſelf-martyrdom, and notwithſtanding the defence of Euſebius, was conſigned by the ſentence of the church to inevitable damnation, on account of his errors in the myſteries of the faith. To queſtion his perdition, therefore, was to deny that the church was the interpreter of the divine intentions. The defence of this part of the *Concluſiones* is written with a boldneſs that could hardly be expected from an Italian of the 15th century. But the hardieſt of theſe propoſitions was that in which it is aſſerted, that faith is not in a man's own power. In defending this and the other propoſitions, which were taxed with hereſy, Pica probably relied leſs on the ſpirit and ability of his juſtification, than on his own high rank and ſtation, together with the countenance and protection of his powerful friends, particularly the Medici, whoſe liberality of ſentiment in regard to religious points was ſo notorious, that even Leo X. has been directly charged, not only with hereſy, but infidelity *.

* *Milner's Hiſt. of the Church*, vol. iv.

By the Cabala, a term at this time generally miſapprehended, was underſtood ſometimes a ſpecies of divine magic operating by the agency of good ſpirits, as magic commonly ſo called was ſuppoſed to do by that of evil beings; but the true definition of it, as received by the beſt of its profeſſors, is given by Reuchlinus (A), in his treatiſe addreſſed to Lorenzo de Medici, *Divinæ Revelationis ad ſalutiferam Dei et formarum ſeparatarum contemplationem traditæ ſymbolica receptio*,—a ſymbolic acceptation of the Moſaic hiſtory (for that is meant by *divina revelatio*) which produced a pure and perfect acquaintance with the nature of the divinity and of ſpirits; and according to the opinions of ſome, which ſeem to be revived by the modern Swedenborgians, this knowledge, when ſublimed to the higheſt perfection it was capable of, and accompanied with perfect purity, was believed to

(A) This treatiſe, which contains the whole learning upon a ſubject once held in the higheſt veneration by men of learning, is very curious, and is to be found in the folio edition of Mirandola's works, publiſhed at Baſil, in 1557.

to raiſe the mind to an abſolute familiarity with good angels, by whoſe aſſiſtance the poſſeſſors of the cabalic ſecrets were enabled to do miraculous things. This art was derived from the rabbinical doctors, who were at firſt called Thalmudiſts; and, about the middle of the 15th century, according to Pica de Mirandola †, its profeſſors were denominated Cabalici, Cabalæi, or Cabaliſtæ, according to their different degrees of perfection: they afterwards, however, departed from their maſters the Thalmudiſts; the latter, according to Reuchlinus, being chiefly intent upon the law and the explanation of it, while the former, paying leſs regard to what concerned human affairs, aimed chiefly at elevation of mind and thought. The ideas and doctrines of the Cabaliſts ſeem to have been well known to Milton, and perhaps ſuggeſted ſome paſſages in Paradiſe Loſt. In Reuchlinus's Expoſition of their myſteries there is a curious paſſage deſcribing the ſpeech of the Deity to the heavenly ſpirits after the fall of Adam, with the future proſpect of redemption by the incarnation of the Meſſiah, whom the Cabaliſts recogniſed in the character of a celeſtial Adam (B); and, among the books relating to theſe doctrines, which are ſaid to be loſt, mention is made of *Liber Bellorum Domini*. The myſteries of the Pythagorean philoſophy, which, according to Philolaus apud Reuchlinum, ſprung from the ſame ſource, were alſo ſtudied and taught with great fervency during this period. Mirandola and Paulus Riccius were the firſt who explained the Cabaliſtic myſteries in Latin, and the former, in his Apology, has employed much labour and learning in defending them, as well as the ſcience of natural magic, from the vulgar idea that necromancy was at the bottom of them. His writings, however, upon that ſubject were few, and we do not know whether they ſtill exiſt; but it may be collected from the following propoſition in his *Concluſiones*, and ſome others of a ſimilar nature, that he, like all the ſcholars of his time, had beſtowed much attention upon this uſeleſs learning: "Qui ſcierit quid ſit denarius in Arithmetica formali, et cognoverit natura primi numeri ſphærici, ſciet ſecretum quinquaginta portarum intelligentiæ et magni jobelæi, et milleſimæ generationis, et regnum omnium ſeculorum." Thoſe who are well acquainted with the tenets of the modern millenarians will be able to tell whether there be any connection between them and the alluſions in the concluding part of this propoſition.

† *Reuchlinus de Arte Cabaliſt.*

Magic alſo entered deeply into the learning of this era. This compriſes two diſtinct ſciences, that of natural magic, and that of dæmonology: the firſt was concerned only in the properties of numbers and figures, and ſome of the more hidden properties of nature. This knowledge enabled its poſſeſſors to produce many effects from natural cauſes, which, when ſcience was leſs diffuſed than at preſent, appeared to be the effect of ſomething ſuperior to the common limits of human power. Albertus, commonly called Magnus, the friend and tutor of Roger Bacon, was the moſt celebrated of thoſe who excelled in this ſort of knowledge. This ſcience has been productive of many admirable diſcoveries in mathematics and chemiſtry. Magic, in its common ſignification, or necromancy, was alſo eagerly ſtudied at this time, as appears from Cornelius Agrippa's ſtrange work upon that ſubject; and we may judge of the eſtimation in which it was held, by the confeſſion that writer makes in his book *De vanitate omnium Scientiarum*, that while he profeſſed that ſcience, he derived more credit and profit from it, than from any other uſe he ever could make of his learning. The firſt maſter in this way was ſaid to be * Solomon, whoſe magic ring and glaſs are ſtill famous in eaſtern dæmonology.

* *P. Crinitus de honeſta Diſcip.* lib. ix. c. 5.

But the moſt dangerous, the moſt popular, and the moſt pernicious deluſion which the darkneſs of the preceding ages had entailed upon mankind, was aſtrology, which will perhaps never be utterly exterminated from the minds of the vulgar, but which then poſſeſſed all ranks. When theſe conſiderations are taken into the account, it muſt be looked upon as no deſpicable application of learning and talents, to have expoſed the fallacy and abſurdity of this deluſion; and when we recollect the great learning and credit of ſome of its upholders, among whom our countryman Roger Bacon was the moſt eſteemed; the almoſt univerſal belief entertained of it, and the few lights which mankind then poſſeſſed, as to the real and conſtant laws obeyed by the celeſtial bodies; it cannot be denied that the twelve books written by Mirandola againſt aſtrology, the effect of which, in opening men's eyes upon that ſubject is teſtified by a reſpectable cotemporary author, were the work of a very ſuperior and enlightened mind. When we congratulate ourſelves upon our freedom from theſe ſuperſtitions, we ought not to forget, that we owe ſomething to thoſe who gave the firſt blow to them. Proud of the lights of the age we live in, when aſtrology and ſuch like cheats are no longer in vogue, we are too apt to overlook the merit of thoſe exertions which firſt expoſed and refuted them; and to perſuade ourſelves, that in theſe days of genius and philoſophy, ſuch exertions would have been unneceſſary; not recollecting that if we enjoy many ſuperiorities of this kind, we are leſs indebted for them to our own genius than to the labours of thoſe who firſt paved the way for the detection of ſuperſtitious errors; our merit is, that we do not ſhut our eyes to the light of ſcience; but while we enjoy its blaze, we ought to be grateful to thoſe who ſtruck the firſt ſparks.

John Pica of Mirandola has been repreſented by writers, whoſe ideas are taken from the encomiums of his cotemporaries, as a mighty prodigy of learning and genius. The diſtaſte which the preſent times entertain towards thoſe ſubjects upon which he wrote, renders it very difficult, upon a review of his works, to think thoſe encomiums juſtified. But making allowance for this change of opinion, and weighing the impartial teſtimony of his equals, and the early age at which he obtained their admiration, it may be fairly concluded, he was in reality, a man of very extraordinary powers. Theſe memoirs are principally collected from his letters, and the account given of him by his nephew Franciſco, himſelf

(B) Conjicimus ſane, alterum eſſe Adam cæleſtem angelis in cœlo demonſtratum, unum ex Deo, quem verbo fecerat, et alterum eſſe Adam terrenum, repulſum à Deo, quem ex luto manibus ſuis finxerat. *Reuchlinus*, p. 750.

Pica, Picard.

felf an eminent fcholar. Such a biographer might naturally be fufpected of partiality; but the evidence of other writers fully confirms his account. Paulus Jovius, in his *Elogia Doctorum Virorum*, gives the following character of him *. "John Pica of Mirandola, has been juftly ftyled the phœnix; for in him, the immortal gods, befides the fplendour of his family, affembled all the rareft gifts of body and mind."

* P. 92.

Petrus Riccius, commonly called Petrus Crinitus, who was the pupil of Politian and the companion of Mirandola, laments the death of him and Politian, which happened in the fame year, as a public misfortune, more feverely felt at that particular time, when learning, obftructed by the incurfion of the French into Italy, wanted the fupport and affiftance of fuch men ‡. To thefe may be added the teftimony of Hieronymus Savanarola, who, though afterwards put to death by Pope Alexander for a heretic, was a man of great confideration on account of his learning and talents. In a difpute which took place between him and Mirandola, concerning the philofophy of the ancients; the former, yielding to the fuperiority of his opponent, rofe up and embracing him faid, "Unus tu es, Pice, ætate noftra qui omnium veterum philofophiam ac religionis Chriftianæ præcepta et leges percalleas ||." The following epitaph, written by Hercules Strozza, is preferved by Paulus Jovius:

‡ *Pet. Crin. de honesta Difcip.*

|| *Ib.* iii. c. 2.

Joannes jacet hic Mirandola; cætera norunt
Et Tagus et Ganges, forfan et Antipodes.

Dr Johnfon, in his Effay on Epitaphs, has taken notice of this pompous diftich, as a warning to epitaph writers. "Thus, fays he, have their expectations been difappointed, who honoured Picus of Mirandola with this pompous epitaph. His name, then celebrated in the remoteft corners of the earth, is now almoft forgotten; and his works, then ftudied, admired, and applauded, are now mouldering in obfcurity." *Monthly Mag.*

PICARD, a native of the Netherlands, who founded a fect the profeffors of which were called *Picards*. See PICARDS.

PICARD, *John*, an able mathematician, and one of the moft learned aftronomers of the 17th century, was born at Fleche, and became prieft and prior of Rillie in Anjou. Going to Paris, he was in 1666 received into the Academy of Sciences in quality of aftronomer. In 1671, he was fent, by order of the king, to the caftle of Uraniburg, built by Tycho Brahe in Denmark, to make aftronomical obfervations there; and from thence he brought the original manufcripts wrote by Tycho Brahe, which are the more valuable as they differ in many places from the printed copies, and contain a book more than has yet appeared. He made important difcoveries in aftronomy; and was the firft who travelled through feveral parts of France, to meafure a degree of the meridian. His works are, 1. A treatife on levelling. 2. Fragments of dioptrics. 3. *Experimenta circa aquas effluentes*. 4. *De menfuris*. 5. *De menfura liquidorum & aridorum*. 6. A voyage to Uraniburg, or aftronomical obfervations made in Denmark. 7. Aftronomical obfervations made in feveral parts of France, &c. Thefe, and fome other of his works, which are much efteemed, are in the fixth and feventh volumes of the Memoirs of the Academy of Sciences.

Picard.

PICARDS, a religious fect which arofe in Bohemia in the 15th century.

Picard, the author of this fect, from whom it derived its name, drew after him, as has been generally faid, a number of men and women, pretending he would reftore them to the primitive ftate of innocence wherein man was created: and accordingly he affumed the title of the *New Adam*. With this pretence he taught his followers to give themfelves up to all impurity; faying that therein confifted the liberty of the fons of God; and that all thofe not of their fect were in bondage. He firft publifhed his notions in Germany and the Low Countries, and perfuaded many people to go naked, and gave them the name of *Adamites*. After this he feized on an ifland in the river Laufnecz, fome leagues from Thabor, the head quarters of Zifca, where he fixed himfelf and his followers. His women were common, but none were allowed to enjoy them without his permiffion: fo that when any man defired a particular woman, he carried her to Picard, who gave him leave in thefe words, *Go, increafe, multiply, and fill the earth.*

At length, however, Zifca, general of the Huffites, (famous for his victories over the emperor Sigifmund), hurt at their abominations, marched againft them, made himfelf mafter of their ifland, and put them all to death except two; whom he fpared, that he might learn their doctrine.

Such is the account which various writers, relying on the authorities of Æneas Sylvius and Varillas, have given of the Picards, who appear to have been a party of the Vaudois, that fled from perfecution in their own country, and fought refuge in Bohemia. It is indeed doubtful whether a fect of this denomination, chargeable with fuch wild principles and fuch licentious conduct, ever exifted: and it is certainly aftonifhing that Mr Bayle, in his art. *Picards*, fhould adopt the reproachful reprefentations of the writers juft mentioned: for it appears probable at leaft that the whole is a calumny invented and propagated in order to difgrace the Picards, merely becaufe they deferted the communion and protefted againft the errors of the church of Rome. Lafitius informs us, that Picard, together with 40 other perfons, befides women and children, fettled in Bohemia in the year 1418. Balbinus the Jefuit, in his *Epitome Rerum Bohemicarum*, lib. ii. gives a fimilar account, and charges on the Picards none of the extravagancies or crimes afcribed to them by Sylvius. Schlecta, fecretary of Ladiflaus, king of Bohemia, in his letters to Erafmus in which he gives a particular account of the Picards, fays that they confidered the pope, cardinals, and bifhops of Rome, as the true Antichrifts, and the adorers of the confecrated elements in the euchariſt as downright idolaters; that they denied the corporal prefence of Chrift in this ordinance; that they condemned the worfhip of faints, prayers for the dead, auricular confeffion, the penance impofed by priefts, the feafts and vigils obferved in the Romifh church; and that they confined themfelves to the obfervance of the fabbath, and of the two great feafts of Chriftmas and Pentecoft. From this account it would appear that they were no other than the Vaudois; and M. de Beaufobre has fhown that they were both of the fame fect, though under different denominations. Befides, it is certain that the Vaudois

were

were settled in Bohemia in the year 1178, where some of them adopted the rites of the Greek, and others those of the Latin church. The former were pretty generally adhered to till the middle of the 14th century, when the establishment of the Latin rites caused great disturbance. On the commencement of the national troubles in Bohemia, on account of the opposition to the papal power (see MORAVIANS), the Picards more publicly avowed and defended their religious opinions; and they formed a considerable body in an island by the river Launitz or Lausnecz, in the district of Bechin, and recurring to arms, were defeated by Zisca. *Encyclop.* art. Picards.

PICARDY, a province in France, is bounded on the north by Hainault, Artois, and the straits of Calais; on the east by Champagne; on the south by the Isle of France; and on the west by Normandy and the English channel (A). This province is long and narrow, being usually compared to a bent arm; and in this figure is nearly 150 miles in length, but not above 40 in breadth, and in many places not above 20. It is generally a level country; and produces wine, fruit of all kinds, plenty of corn, and great quantities of hay: but wood being scarce, most of the inhabitants burn turf. They have, however, some pit-coal, but it is not so good as that of England. It was united to the crown of France in the year 1643; and is supposed to contain 533,000 inhabitants.

Its principal rivers are the Somme, the Oise, the Canche, the Lanthie, the Lys, the Aa, the Scarpe, and the Deule.

The situation of this province on the sea, its many navigable rivers and canals, with the industry of the inhabitants, render it the seat of a flourishing trade. In it are made beautiful silk stuffs, woollen stuffs, coarse linen, lawn, and soap; it also carries on a large trade in corn and pit-coal. In the districts of Calais and Boulogne are annually bred 5000 or 6000 colts, which being afterwards turned loose in the pastures of Normandy, are sold for Norman horses. The fisheries on this coast are also very advantageous. This province was formerly divided into Upper, Middle, and Lower Picardy; and again subdivided into four deputy-governments. The principal town is Amiens.

PICCOLOMINI, ALEXANDER, archbishop of Patras, and a native of Sienna, where he was born about the year 1508, was of an illustrious and ancient family, which came originally from Rome, but afterwards settled at Sienna. He composed with success for the theatre; but he was not more distinguished by his genius, than by the purity of his manners, and his regard to virtue. His charity was very great; and was chiefly exerted in relieving the necessities of men of letters. He has left behind him a number of works in Italian. The most remarkable of which are, 1. Various Dramatic Pieces, which laid the first foundation of his character as a writer. 2. A Treatise on the Sphere. 3. A Theory of the Planets. 4. A Translation of Aristotle's Art of Rhetoric and Poetry, in 4to. 5. A System of Morality, published at Venice, 1575, in 4to; translated into French by Peter de Larivey in 4to; and printed at Paris, 1581. These, with a variety of other works, prove his extensive knowledge in natural philosophy, mathematics, and theology. He was the first who made use of the Italian language in writing upon philosophical subjects. He died at Sienna the 12th of March 1578, aged 70. A particular catalogue of his works may be seen in the Typographical Dictionary. There is one performance ascribed to this author, entitled *Dialogo della bella Creanta delle Donne*, (printed at Milan, 1558, and at Venice, 1574, in 8vo.); which but ill suits the dignity of a prelate. It is filled with maxims which have an evident tendency to hurt the morals of young women. Piccolomini's name, indeed, is not in the title page; and it has all the appearance of being a juvenile production. It is very scarce; and the public would sustain no loss by its being entirely out of print. It was translated into French by F. d'Amboise, and published at Lyons, in 16mo, under the title of *Instruction des jeunes dames*. It was afterwards reprinted in 1583, under that of *Dialogue & Devis des Demoiselles*.

PICCOLOMINI, *Francis*, of the same family with the foregoing, was born in 1520, and taught philosophy with success, for the space of 22 years, in the most celebrated universities of Italy, and afterwards retired to Sienna, where he died, in 1604, at the age of 84. This city went into mourning on his death. His works are, 1. Some Commentaries upon Aristotle, printed at Mayence, 1608, in 4to. 2. *Universa Philosophia de Moribus*, printed at Venice, 1583, in folio. He laboured to revive the doctrine of Plato, and endeavoured also to imitate the manners of that philosopher. He had for his rival the famous James Zabarella, whom he excelled in facility of expression and neatness of discourse; but to whom he was much inferior in point of argument, because he did not examine matters to the bottom as the other did, but pressed too rapidly from one proposition to another.

PICCOLOMINI of *Arragon*, *Octavius*, duke of Amalfi, prince of the Empire, a general of the emperor's army, and knight of the order of the Golden Fleece, was born in 1599. He first bore arms among the Spanish troops in Italy. He afterwards served in the army of Ferdinand II. who sent him to the relief of Bohemia, and entrusted him with the command of the imperial troops in 1634. After having signalized himself at the battle of Nortlingue, he made Marshal de Chatillon raise the siege of St Omer. He had the good fortune to gain a victory over Marquis de Feuquieres in 1639: nor did the loss of the battle of Wolfenbuttel, in 1651, impair his glory. He died on the 10th of August 1656, being five years after, aged 57, without issue; and with the character of an able negotiator and an active general. The celebrated Caprara was his nephew.

PICCOLOMINI,

(A) The origin of the name of this province does not date earlier than A. D. 1200. It was an academical joke; an epithet first applied to the quarrelsome humour of those students in the university of Paris who came from the frontier of France and Flanders, and hence to their country *Valesii Notitia Galliarum*, p. 447. *Longuerac, Description de la France*, p. 52.

PICCOLOMINI, *James*, whose proper name was *Ammanati*, took that of *Piccolomini* in honour of his patron Pius II. He was born in a village near Lucca in 1422. He became bishop of Massa, afterwards of Frescati; a cardinal in 1461, under the name of *Cardinal de Pavie;* and died in 1479, at the age of 57, of an indigestion of figs. He left 8000 pistoles in the bankers hands, which Pope Sixtus IV. claimed; and of which he gave a part to the Hospital of the Holy Ghost. His works, which consist of some Letters, and a history of his own time, were printed at Milan, in 1521, in folio. His history, entitled *Commentaries*, commences the 18th of June 1464, and ends the 6th of December 1469. They may very properly be considered as a Sequel of Pope Pius II.'s Commentaries, which end with the year 1463.

PICCOLOMINI, ÆNEAS SYLVIUS. See PIUS II.

PICENTIA, (Strabo, Pliny), the capital of the Picentini, whose territory, called *Ager Picentinus*, a small district, lay on the Tuscan sea, from the *Promontorium Minervæ*, the south boundary of Campania on the coast, to the river Silarus, the north boundary of Lucania, extending within-land as far as the Samnites and Hirpini, though the exact termination cannot be assigned. The Greeks commonly confound the *Picentini* and *Picentes*, but the Romans carefully distinguish them. The former, with no more than two towns that can be named, *Silernum* and *Picentia;* the situation of both doubtful: only Pliny says the latter stood within-land, at some distance from the sea. Now thought to be *Bicenza*, (Holstenius), in the Principato Citra of Naples.

PICENUM, (Cæsar, Pliny, Florus); PICENUS AGER, (Cicero, Sallust, Livy, Tacitus); *Ager Picentium*, (Varro): a territory of Italy, lying to the east of Umbria, from the Apennine to the Adriatic; on the coast extending from the river Aesis on the north, as far as the *Prætutiani* to the south. In the upper or northern part of their territory the Umbri excluded them from the Apennine, as far as Camerinum, (Strabo); but in the lower or southern part they extended from the Adriatic to the Apennine. A very fruitful territory, and very populous. *Picentes*, the people, (Cicero); from the singular *Picens*, (Livy): different from the *Picentini* on the Tuscan sea, though called so by the Greeks; but Ptolemy calls them *Piceni*, as does also Pliny. Their territory at this day is supposed to form the greatest part of the March of Ancona, (Cluverius).

PICHFORD, in the county of Salop in England; on the south-east side of Shrewsbury, near Condover. It is noted for a spring of pitchy water (from whence some derive its name), on the top of which there always flows a sort of liquid bitumen. Over most of the coal pits in this neighbourhood there lies a stratum of blackish rock; of which, by boiling and grinding, they make pitch and tar, and also distil an oil from it.

PICHINCHA, or PINCHINCA, a mountain in Peru. See PERU, N° 56.

PICKERING, in the north riding of Yorkshire in England, 13 miles from Scarborough, and 125 from London, is a pretty large town belonging to the duchy of Lancaster, on a hill among the wild mountains of Blakemore; having the forest of Pickering on the north, and Pickering-common on the south. It is said to have been built 270 years before Christ by Peridurus, a king of the Britons, who was buried here. It had once a castle, the ruins of which are still to be seen; to whose jurisdiction many of the neighbouring villages were subject: and the adjacent territory, commonly called Pickering-Lath, or the liberty or forest of Pickering, was given by Henry III. to his son Edmund earl of Lancaster. A court is kept here for all actions under 40s. arising within the honour of Pickering.

PICKERY, in *Scots Law*, petty theft, or stealing things of small value.

PICKETS, in fortification, stakes sharp at one end, and sometimes shod with iron, used in laying out the ground, of about three feet long; but, when used for pinning the fascines of a battery, they are from three to five feet long.

PICKETS, in artillery, are about five or six feet long, shod with iron, to pin the park lines, in laying out the boundaries of the park.

PICKETS, in the camp, are also stakes of about six or eight inches long, to fasten the tent cords, in pitching the tents; also, of about four or five feet long, driven into the ground near the tents of the horsemen, to tie their horses to.

PICKET, an out-guard posted before an army, to give notice of an enemy approaching.

PICKET, a kind of punishment so called, where a soldier stands with one foot upon a sharp pointed stake; the time of his standing is limited according to the offence.

PICKLE, a brine or liquor, commonly composed of salt, vinegar, &c. sometimes with the addition of spices, wherein meat, fruit, and other things, are preserved and seasoned.

PICO, one of the Azores islands, is so called from some lofty mountains on it; or rather from one very high mountain, terminating like Teneriffe in a peak, and reputed by some writers equal to it in height. This island lies about four leagues south-west from St George, twelve from Tercera, and about three leagues south-east of Fayal; in W. Long. 28. 21. and N. Lat. 38. 29. The mountain Pico, which gives name to the island, is filled with dismal dark caverns or volcanoes, which frequently vomit out flames, smoke, and ashes, to a great distance. At the foot of this mountain towards the east is a spring of fresh water, generally cold, but sometimes so heated with the subterraneous fire, as to rush forth in torrents with a kind of ebullition like boiling water; equalling that in heat, and sending forth a steam of sulphureous fetid vapours, liquefied stones, minerals, and flakes of earth all on fire, in such quantities, and with such a violence, as to have formed a kind of promontory vulgarly called *Mysterios*, on the declivity of the coast, and at the distance of 1200 paces from the fountain. Such at least is the account of Ortelius; though we do not find this last circumstance of the promontory confirmed by later observations. The circumference of Pico is computed at about 15 leagues: and its most remarkable places are Pico, Lagoas, Santa Cruce or Cruz, San Sebastian, Pesquin, San Rocko, Playa, and Magdalena; the inhabitants of which live wholly on the produce of the island, in great plenty and felicity. The cattle are various, numerous, and excellent in their several kinds: it is the same with the vine; and its juice, prepared into different wines, the best in the Azores.

Besides cedar and other timber, they have a kind of wood which they call *teixo*, solid and hard as iron; and veined, when finely polished, like a rich scarlet tabby; which colour it has in great perfection. The longer it is kept, the more beautiful it grows: hence it is, that the teixo tree is felled only for the king's use or by his order; and is prohibited from being exported as a common article of trade.

Pico *Marina*, a sea fish common at Kongo in Africa, derives its name from the resemblance of its mouth to the beak of a woodpecker. It is of a large size, and prodigious strength, has four fins on its back, three under its belly, and one on each side of its head; its tail is large and forked, by which it cuts the waves with surprising force and velocity. It is at war with every fish that swims, and with every thing it meets in its way, without being intimidated by the largest vessels; a surprising instance of which intrepidity, we are told by some missionaries, whose ship was attacked by one of them, near these coasts, in the dead of night. The violence of the shock which it gave to the vessel quickly awakened the captain and the rest of the people; who immediately ran to the ship's side, where they perceived, by moon light, this huge monster fastened by its forehead to the vessel, and making the strongest efforts to disengage itself; upon which some of them tried to pierce him with their pikes, but he got off before they could accomplish their aim. On the next morning, upon visiting that side of the vessel, they found a piece of the bony snout stuck fast into the wood, and two or three inches of it projecting outwards. In the inside of the ship, there was discovered about five or six inches more of the point of the horn, which had penetrated through the plank. But we must observe, that the credulity of the times probably rendered this animal thus formidable.

Mod. Univ. History, vol. xiii. p. 46. &c.

PICQUERING, a flying war, or skirmish, made by soldiers detached from two armies for pillage, or before a main battle begins.

PICQUET, or Picket. See Piquet.

PICRAMNIA, a genus of plants belonging to the diœcia class; and in the natural method ranking with those that are doubtful. See Botany *Index*.

PICRANIA amara, or *Bitter Wood*, is a tall and beautiful timber tree, common in the woods of Jamaica, belonging to the pentandria class of plants. The name is expressive of its sensible qualities.

Every part of this tree is intensely bitter; and even after the tree has been laid for floors many years, whoever rubs or scrapes the wood, feels a great degree of bitterness in their mouth or throat. Cabinet-work made of this wood is very useful, as no insect will live near it.

This tree has a great affinity to the *Quassia Amara* of Linnæus; in lieu of which it is used as an antiseptic in putrid fevers. When used, less of it will do than of the *Quassia Amara* of Surinam. See Quassia, Botany and Materia Medica *Index*.

PICRIS, Ox-tongue; a genus of plants, belonging to the syngenesia class. See Botany *Index*.

PICRIUM, a genus of plants, belonging to the tetrandria class; and in the natural method ranking with those that are doubtful. See Botany *Index*.

PICTET, Benedict, a celebrated divine, was born at Geneva, in 1655, of a distinguished family, and prosecuted his studies with great success. After having travelled into Holland and England, he taught theology in his own country with an extraordinary reputation. The university of Leyden, after the death of Spantreina, solicited him to come and fill his place; but he thought that his own country had the best right to his services: and for that generosity he received its thanks by the mouth of the members of council. A languishing disorder, occasioned by too much fatigue, hastened his death: which happened on the 9th of June 1724, at the age of 69 years. This minister had much sweetness and affability in his manner. The poor found in him a comforter and a father. He published a great number of works in Latin and French, which are much esteemed in Protestant countries. The principal of these are, 1. A System of Christian Theology in Latin, 3 vols. in 4to; the best edition of which is that of 1721. 2. Christian Morality, printed at Geneva, 1710, 8 vols. in 12mo. 3. The History of the 11th and 12th centuries; intended as a sequel to that of Sueur, printed in 1713, 2 vols. in 4to. The Continuator is held in higher estimation than the first author. 4. Several Controversial Treatises. 5. A great number of tracts on morality and piety; among which we must distinguish "the Art of Living and Dying well;" published at Geneva, 1705, in 12mo. 6. Some Letters. 7. Some Sermons, from 1697 to 1721; 4 vols. in 8vo. With a vast number of other books, the names of which it would be tedious to mention; but which, as Mr Sennebier says, "all show evident marks of piety and good sense."

Pictet, *John-Louis*, a counsellor of Geneva, born in 1739, was of the same family. He was member of the Council of Two Hundred; Counsellor of State and Syndic; and died in 1781. He applied himself to the study of astronomy, and made several voyages into France and England for his improvement. Few men were ever blessed with a clearer or more enlightened understanding. He has left in manuscript the "Journal of a Voyage which he made to Russia and Siberia in 1768 and 1769, in order to observe the transit of Venus over the sun's disk:" A work very interesting, from the lively descriptions which it gives both of men and of nature.

PICTLAND. See Pentland.

PICTS, the name of one of those nations who anciently possessed the north of Britain. It is generally believed that they were so called from their custom of painting their bodies; an opinion which Camden supports with great erudition. (See Gough's edition, Vol. I. p. xci. of the preface). It is certainly liable, however, to considerable objections; for as this custom prevailed among the other ancient inhabitants of Britain, who used the *glastum* of Pliny and the *vitrum* of Mela for the like purpose, it may be asked, Why the name of *Picti* was confined by the Romans to only one tribe, when it was equally applicable to many others? Why should they design them only by an epithet, without ever annexing their proper name? Or why should they impose a new name on this people only, when they give their proper name to every other tribe which they have occasion to speak of? As these questions cannot be answered in any satisfactory manner, it is plain we must look for some other derivation of the name.

Name.

The Highlanders of Scotland, who speak the ancient language of Caledonia, express the name of this once famous

mous nation by the term *Pictich;* a name familiar to the ears of the most illiterate, who could never have derived it from the Roman authors. The word *Pictich* means *pilferers* or *plunderers*. The appellation was probably imposed upon this people by their neighbours, or assumed by themselves, some time after the reign of Caracalla, when the unguarded state of the Roman province, on which this people bordered, gave them frequent opportunities of making incursions thither, and committing depredations. Accordingly this name seems to have been unknown till the end of the 3d century. Eumenius the panegyrist is the first Roman author who mentions this people under their new name of *Pictich*, or, with a Latin termination, *Picti*. When we say that this name may have been probably assumed for the reason just now mentioned, we must observe, that, in those days of violence, the character of a robber was attended with no disgrace. If he had the address to form his schemes well, and to execute them successfully, he was rather praised than blamed for his conduct; providing he made no encroachments on the property of his own tribe or any of its allies. We mean this as no peculiar stigma upon the Picts; for other nations of antiquity, in the like rude state, thought and acted as they did. See *Thucydides*, lib. iii. p. 3. and *Virg. Æn.* vii. 745 et 749.

2 Origin. Concerning the origin of the Picts, authors are much divided. Boethius derives them from the Agathyrsi, Pomponius Lætus from the Germans, Bede from the Scythians, Camden (A) and Father Innes from the ancient Britons, Stillingfleet from a people inhabiting the Cimbrica Chersonesus, and Keating and O'Flaherty, on the authority of the Cashel Psalter, derive them from the Thracians. But the most probable opinion is, that they were the descendants of the old Caledonians. Several reasons are urged in support of this opinion by Dr Macpherson; and the words of Eumenes, "Caledonum, aliorumque Pictorum, silvas," &c. plainly imply that the Picts and Caledonians were one and the same people.

As there has been much dispute about the origin of the Picts, so there has been likewise about their language. There are many reasons which make it plain that their tongue was the Gaelic or Celtic; and these reasons are a further confirmation of their having been of Caledonian extract. Through the east and north-east coasts of Scotland (which were possessed by the Picts) we meet
3 Language. with an innumerable list of names of places, rivers, mountains, &c. which are manifestly Gaelic. From a very old register of the priory of St Andrew's (Dalrymple's Collections, p. 122.) it appears, that in the days of Hungus, the last Pictish king of that name, St Andrew's was called *Mukross;* and that the town now called *Queensferry* had the name of *Ardchinneachan*. Both these words are plain Gaelic. The first signifies "the heath or promontory of boars;" and the latter, "the height or peninsula of Kenneth." In the list of Pictish kings published by Father Innes, most of the names are obviously Gaelic, and in many instances the same with the names in the list of Scottish or Caledonian kings published by the same author. Had Innes understood any thing of this language, he would not have supposed with Camden that the Picts spoke the British tongue. It was unlucky that the two words on which they built their conjecture (*Strath* and *Aber*) are as common in the Gaelic as they could have been in the British, and at this day make a part of the names of places in countries to which the Pictish empire never extended. The names of *Strathfillan* and *Lochaber* may serve as instances.

The venerable Bede, as much a stranger to the Celtic as either of the antiquaries just now mentioned, is equally unhappy in the specimen which he gives of the Pictish language in the word *penuahel*, "the head of the wall." Allowing the commutation of the initial *p* into *c*, as in some other cases, this word has still the same meaning in Gaelic which Bede gives it in the Pictish. It is true, there might have been then, as well as now, a considerable difference between various dialects of the Celtic; and thus, perhaps, that pious author was led to discover five languages in Britain *agreeably to the five books of Moses:* A conceit from which the good man derived a great deal of harmless satisfaction.

The Picts of the earliest ages, as appears from the joint testimony of all writers who have examined the 4 Territory.
subject, possessed only the east and north-east coast of Scotland. On one side, the ancient Drumalbin, or that ridge of mountains reaching from Lochlomond near Dumbarton to the frith of Tain, which separates the county of Sutherland from a part of Ross, was the boundary of the Pictish dominions. Accordingly we find in the life of Columba, that, in travelling to the palace of Brudius, king of the Picts, he travelled over Drumalbin, the *Dorsum Britanniæ* of Adamnan. On the other side, the territory of the Picts was bounded by the Roman province. After Britain was relinquished by the emperor Honorius, they and the Saxons by turns were masters of those countries which lie between the frith of Edinburgh and the river Tweed. We learn from Bede, that the Saxons were masters of Galloway when he finished his Ecclesiastical History. The Picts, however, made a conquest of that country soon after; so that, before the extinction of their monarchy, all the territories bounded on the one side by the Forth and Clyde, and on the other by the Tweed and Solway, fell into their hands.

The history of the Picts, as well as of all the other 5 History.
ancient inhabitants of Britain, is involved in obscurity. The Irish historians give us a long list of Pictish kings, who reigned over Pictavia for the space of 11 or 13 centuries before the Christian era. After them Innes, in his Critical Essay, gives us a list of above fifty, of whom no less than five held the sceptre, each for a whole century. It is probable that these writers had confounded the history of the Picts with that of their ancestors the old Caledonians. In any other view, their accounts of them are highly fabulous; and have been long ago confuted by Dr Macpherson of Slate, an antiquary of much learning and research. The Picts, as has been already

(A) See *Gough's edition of Camden*, Vol. I. Preface, p. xc. and the *Ancient Universal History*, Vol. XVII. p. 39, &c.

Picts. already obſerved, were probably not known by that name before the 2d or 3d century. Adamnan, abbot of Iona, is the firſt author that expreſsly mentions any Pictiſh king; and the oldeſt after him is Bede. We are informed by theſe two writers, that St Columba converted Brudius king of the Picts to the Chriſtian faith. Columba came into Britain in the year of the vulgar era 565. Before that period we have no general record to aſcertain ſo much as the name of any Pictiſh king. The hiſtory of *Druſt* or *Dreſt*, who is ſaid to have reigned over the Picts in the beginning of the fifth century, when St Ninian firſt preached the goſpel to that nation, has all the appearance of fiction (B). His having reigned a hundred years, and his putting an end to a hundred wars, are ſtories which exceed all the bounds of probability.

Brudius, the contemporary of Columba, is the firſt Pictiſh king mentioned by any writer of authority.

What figure his anceſtors made, or who were his ſucceſſors on the throne of Pictavia, cannot be aſcertained. Bede informs us, that, during the reign of one of them, the Picts killed Egfred king of Northumberland in battle, and deſtroyed the greateſt part of his army. The ſame author mentions another of their kings called *Naitan*, for whom he had a particular regard. It was to this *Naitan* that Ceolfrid, abbot of Wiremouth, wrote his famous letter concerning Eaſter and the Tonſure (C); a letter in which Bede himſelf is ſuppoſed to have had a principal hand. Roger Hoveden and Simon of Durham mention two other Pictiſh kings *Onnuſt* and *Kinoth*, the firſt of whom died in 761, and the latter flouriſhed about the 774, and gave an aſylum to Alfred of Northumberland, who was much about that time expelled his kingdom. The accounts given by the Scots hiſtorians of ſeveral other Pictiſh kings cannot be depended on; nor are the ſtories told by the Britiſh hiſtorians, Geoffroy of Monmouth and the author of the *Eulogium Britanniæ*, worthy of much greater credit.

In the ninth century the Pictiſh nation was totally ſubdued by the Scots in the reign of Kenneth Macalpin. Since that time their name has been loſt in that of the conquerors, with whom they were incorporated after this conqueſt; however, they ſeem to have been treated by the Scottiſh kings with great lenity, ſo that for ſome ages after they commanded a great deal of reſpect. The prior of Hogulſtead, an old Engliſh hiſtorian, relates, that they made a conſiderable figure in the army of David the Saint, in his diſputes with Stephen king of England. In a battle fought in the year 1136, by the Engliſh on one ſide, and the Scots and Picts on the other, the latter inſiſted on their hereditary right of leading the van of the Scots army, and were indulged in that requeſt by the king.

The principal ſeat of the Pictiſh kings was at Abernethy. Brudius, however, as appears from the accounts given by Adamnan, in his life of Columba, had a palace at Inverneſs, which was probably near the extremity of his territory in that quarter; for there is no good reaſon for believing, with Camden, that this king had any property in the Weſtern Iſles, or that he had made a gift of Iona to St Columba when he viſited him in that place.

Picts ‖ Picturefque Beauty.

6 Manners. With reſpect to the manners and cuſtoms of the Picts, there is no reaſon to ſuppoſe they were any other than thoſe of the old Caledonians and Scots, of which many particulars are related in the Greek and Roman writers who have occaſion to ſpeak of thoſe nations.

Upon the decline of the Roman empire, cohorts of barbarians were raiſed, and Picts were invited into the ſervice, by Honorius, when peace was every where reſtored, and were named *Honoriaci*. Thoſe under Conſtantine opened the paſſes of the Pyrenean mountains, and let the barbarous nations into Spain. From this period we date the civilization of their manners, which happened after they had by themſelves, and then with the Scots, ravaged this Roman province.

PICTS Wall, in antiquity, a wall begun by the emperor Adrian, on the northern bounds of England, to prevent the incurſions of the Picts and Scots. It was firſt made only of turf ſtrengthened with paliſadoes, till the emperor Severus, coming into Britain in perſon, built it with ſolid ſtone. This wall, part of which ſtill remains, began at the entrance of the Solway frith in Cumberland, and running north-eaſt extended to the German ocean. See ADRIAN and SEVERUS.

PICTURE, a piece of painting, or a ſubject repreſented in colours, on wood, canvas, paper, or the like. See PAINTING.

PICTURESQUE BEAUTY, ſays a late writer on that ſubject, refers to "ſuch beautiful objects as are ſuited to the pencil." This epithet is chiefly applied to the works of nature, though it will often apply to works of art alſo. Thoſe objects are moſt properly denominated pictureſque, which are diſpoſed by the hand of nature with a mixture of *varied rudeneſs*, *ſimplicity*, and *grandeur*. A plain neat garden, with little variation in its plan, and no ſtriking grandeur in its poſition, diſplays too much of art, deſign, and uniformity, to be called pictureſque. "The ideas of *neat* and *ſmooth* (ſays Mr Gilpin), inſtead of being pictureſque, in fact diſqualify the object in which they reſide from any pretenſions to pictureſque beauty. Nay, farther, we do not ſcruple to aſſert, that roughneſs forms the moſt eſſential point of difference between the beautiful and the pictureſque; as it ſeems to be that particular quality which makes

(B) According to Camden, this converſion happened about the year 630, in the ſouthern Pictiſh provinces; while the northern, which were ſeparated by fruitful mountains, were converted by Columba.

(C) We are told by ſome authors that Columba taught the Picts to celebrate Eaſter always on a Sunday between the 14th and 20th of March, and to obſerve a different method of tonſure from the Romans, leaving an imperfect appearance of a crown. This occaſioned much diſpute till Naitan brought his ſubjects at length to the Roman rule. In that age many of the Picts went on a pilgrimage to Rome, according to the cuſtom of the times; and amongſt the reſt we find two perſons mentioned in the antiquities of St Peter's church. *Aſterius* count of the Picts, and *Syra* with his countrymen, performed their vow.

Picturesque Beauty.

makes objects chiefly pleasing in painting. I use the general term *roughness*; but properly speaking roughness relates only to the surfaces of bodies: when we speak of their delineation, we use the word *ruggedness*. Both ideas, however, equally enter into the picturesque, and both are observable in the smaller as well as in the larger parts of nature; in the outline and bark of a tree, as in the rude summit and craggy sides of a mountain.

Let us then examine our theory by an appeal to experience, and try how far these qualities enter into the idea of picturesque beauty, and how far they mark that difference among objects which is the ground of our inquiry.

"A piece of Palladian architecture may be elegant in the last degree; the proportion of its parts, the propriety of its ornaments, and the symmetry of the whole, may be highly pleasing; but if we introduce it in a picture, it immediately becomes a formal object, and ceases to please. Should we wish to give it picturesque beauty, we must use the mallet instead of the chissel; we must beat down one half of it, deface the other, and throw the mutilated members around in heaps; in short, from a smooth building we must turn it into a rough ruin. No painter who had the choice of the two objects would hesitate a moment.

"Again, why does an elegant piece of garden-ground make no figure on canvas? the shape is pleasing, the combination of the objects harmonious, and the winding of the walk in the very line of beauty. All this is true; but the smoothness of the whole, though right and as it should be in nature, offends in picture. Turn the lawn into a piece of broken ground, plant rugged oaks instead of flowering shrubs, break the edges of the walk, give it the rudeness of a road, mark it with wheel tracks, and scatter around a few stones and brushwood; in a word, instead of making the whole smooth, make it rough, and you make it also picturesque. All the other ingredients of beauty it already possessed." On the whole, picturesque composition consists in uniting in one whole, a variety of parts, and these parts can only be obtained from rough objects.

It is possible, therefore, to find picturesque objects among works of art, and it is possible to make objects so; but the grand scene of picturesque beauty is nature in all its original variety, and in all its irregular grandeur. "We seek it (says our author) among all the ingredients of landscape, trees, rocks, broken grounds, woods, rivers, lakes, plains, valleys, mountains, and distances. These objects in themselves produce infinite variety; no two rocks or trees are exactly the same; they are varied a second time by combination; and almost as much a third time by different lights and shades and other aerial effects. Sometimes we find among them the exhibition of a whole, but oftener we find only beautiful parts."

Sublimity or grandeur alone cannot make an object picturesque: for, as our author remarks, "however grand the mountain or the rocks may be, it has no claim to this epithet, unless its form, its colour, or its accompaniments, have some degree of beauty. Nothing can be more sublime than the ocean; but wholly unaccompanied, it has little of the picturesque. When we talk therefore of a sublime object, we always understand that it is also beautiful; and we call it sublime or beautiful only as the ideas of sublimity or simple beauty prevail. But it is not only the form and the composition of the objects of landscape which the picturesque eye examines; it connects them with the atmosphere, and seeks for all those various effects which are produced from that vast and wonderful storehouse of nature. Nor is there in travelling a greater pleasure than when a scene of grandeur bursts unexpectedly upon the eye, accompanied with some accidental circumstance of the atmosphere which harmonizes with it, and gives it double value."

There are few places so barren as to afford no picturesque scene.

————Believe the muse,
She does not know that inauspicious spot
Where beauty is thus niggard of her store.
Believe the muse, through this terrestrial waste
The seeds of grace are sown, profusely sown,
Even where we least may hope.——

Mr Gilpin mentions the great military road between Newcastle and Carlisle as the most barren tract of country in England; and yet there, he says, there is "always something to amuse the eye. The interchangeable patches of heath and green-sward make an agreeable variety. Often too on these vast tracts of intersecting grounds we see beautiful lights, softening off along the sides of hills; and often we see them adorned with cattle, flocks of sheep, heath-cocks, grous, plover, and flights of other wild fowl. A group of cattle standing in the shade on the edge of a dark hill, and relieved by a lighter distance beyond them, will often make a complete picture without any other accompaniment. In many other situations also we find them wonderfully pleasing, and capable of making pictures amidst all the deficiencies of landscape. Even a winding road itself is an object of beauty; while the richness of the heath on each side, with the little hillocks and crumbling earth, give many an excellent lesson for a foreground. When we have no opportunity of examining the grand scenery of nature, we have everywhere at least the means of observing with what a multiplicity of parts, and yet with what general simplicity, she covers every suface.

"But if we let the imagination loose, even scenes like these administer great amusement. The imagination can plant hills; can form rivers and lakes in valleys; can build castles and abbeys; and, if it find no other amusement, can dilate itself in vast ideas of space."

Mr Gilpin, after describing such objects as may be called picturesque, proceeds to consider their sources of amusement. We cannot follow our ingenious author through the whole of this consideration, and shall therefore finish our article with a short quotation from the beginning of it. "We might begin (says he) in moral style, and consider the objects of nature in a higher light than merely as amusement. We might observe, that a search after beauty should naturally lead the mind to the great origin of all beauty; to the

———— first good, first perfect, and first fair.

But though in theory this seems a natural climax, we insist the less upon it, as in fact we have scarce ground to hope that every admirer of picturesque beauty is an

admirer

admirer alſo of the beauty of virtue; and that every lover of nature reflects, that

> Nature is but a name for an *effect*,
> Whoſe *cauſe* is God.————————

If, however, the admirer of nature can turn his amuſements to a higher purpoſe; if its great ſcenes can inſpire him with religious awe, or its tranquil ſcenes with that complacency of mind which is ſo nearly allied that benevolence, it is certainly the better. *Apponat lucro.* It is ſo much into the bargain; for we dare not promiſe him more from picturesque travel than a rational and agreeable amuſement. Yet even this may be of ſome uſe in an age teeming with licentions pleaſure; and may in this light at leaſt be conſidered as having a moral tendency."

PICUIPINIMA, is the Braſilian name of a ſpecies of pigeon, which is ſo very ſmall as ſcarcely to exceed the lark in ſize.

PICUMNUS and PILUMNUS, were two Roman deities, who preſided over the auſpices required before the celebration of nuptials. Pilumnus was ſuppoſed to patronize children, as his name ſeems in ſome manner to indicate *quod pellat mala infantiæ.* The manuring of land was firſt invented by Picumnus, from which reaſon he is called *Sterquilinius.* Pilumnus is alſo invoked as the god of bakers and millers, as he is ſaid to have firſt invented the art of grinding corn.

PICUS, the WOODPECKER, a genus of birds belonging to the order of picæ. See ORNITHOLOGY *Index.*

PICUS (fab. hiſt.), a king of Latium, ſon of Saturn. He married Venilia, alſo called Canens, by whom he had Faunus. He was tenderly loved by the goddeſs Pomona, and he returned her affection. As he was one day hunting in the woods, he was met by Circe, who became deeply enamoured of him, and who changed him into a woodpecker, called by the name of *picus* among the Latins. His wife Venilia was ſo diſconſolate when ſhe was informed of his death, that ſhe pined away. Some ſuppoſe that Picus was the ſon of Pilumnus, and that he gave out prophecies to his ſubjects by means of a favourite woodpecker; from which circumſtance originated the fable of his being metamorphoſed into a bird.

PICUS, *John Francis*, prince of Mirandola, nephew of John Pica or Picus, mentioned above, was born about the year 1469. He cultivated learning and the ſciences after the example of his uncle; but he had a principality and dominions to ſuperintend, which involved him in great troubles, and at laſt coſt him his life. He was twice driven from his principality, and twice reſtored; and at laſt, in 1533, was, together with his eldeſt ſon Albert, aſſaſſinated in his own caſtle by his nephew Galeoti. He was a great lover of letters; and ſuch of his works as were then compoſed were inſerted in the Straſburgh edition of his uncle's in 1504, and continued in future impreſſions, beſides ſome others which were never collected.

PIECE, in matters of money, ſignifies ſometimes the ſame thing with ſpecies; and ſometimes, by adding the value of the pieces, it is uſed to expreſs ſuch as have no other particular name. For the piece of eight, or piaſtre, ſee *MONEY Table.*

PIECE, is alſo a kind of money of account, or rather manner of accounting, uſed among the negroes on the coaſt of Angola in Africa. See *MONEY Table.*

PIECE, in *Heraldry*, denotes an ordinary or charge. The honourable pieces of the ſhield are the chief, feſs, bend, pale, bar, croſs, ſaltier, chevron, and in general all thoſe which may take up one-third of the field, when alone, and in what manner ſoever it be. See HERALDRY.

PIECES, in the military art, include all ſorts of great guns and mortars. Battering pieces are the larger ſort of guns uſed at ſieges for making the breaches; ſuch are the 24-pounder and culverine, the one carrying a 24 and the other an 18 pound ball. Field-pieces are 12-pounds, demiculverines, 6-pounders, ſackers, minions, and 3-pounders, which march with the army, and encamp always behind the ſecond line, but in day of battle are in the front. A ſoldier's firelock is likewiſe called his *piece.*

PIEDMONT, a country of Italy, having formerly the title of a principality, is bounded on the north by Savoy and Italy; on the weſt by France; on the ſouth by the Mediterranean and the republic of Genoa; and on the eaſt by the duchies of Montferrat and Milan; extending about 150 miles from north to ſouth, but much leſs from eaſt to weſt. It is called Piedmont, and in Latin *Piedmontium*, from its ſituation at the foot of the mountains, or Alps, which ſeparate France from Italy. This country is in ſome parts mountainous, but is everywhere very fruitful. The plains produce fine corn, and Montferrat and the Milaneſe yield great quantities of Turkey wheat, which commonly ſerves for bread, and with which the people of the middle rank mix rye; the pods are uſed for fuel, and the ſtalks being thick ſerve to mend the roads. The hills produce plenty of wine, which, like the Italian wines, is very luſcious when new, eſpecially the white. There is alſo a tartiſh red wine called *vino bruſco*, ſaid to be very wholeſome for fat people, and, on the other hand, the ſweet wine is recommended as a ſtomachic. The neighbourhood of Turin is famous for its fine fruits, and many long walks of cheſnut and mulberry trees, which produce both pleaſure and profit. Marons, or large cheſnuts, are a favourite dainty among the common people. Theſe are put into an oven, and, when thoroughly hot, and cooled in red wine, are dryed a ſecond time in the oven, and afterwards eaten cold. Truffles grow here in ſuch abundanee, that Piedmont has obtained the name of the *truffle country.* Some are black, others white marbled with red. Their price is rated according to their ſize. Sometimes they are found of 12 or 14 pounds weight; and many country people earn from 60 to 70 dollars a-year merely by digging for them. The trade in cattle is ſaid to bring into Piedmont no leſs than three millions of livres per annum. The cultivation of ſilk is alſo a profitable article, the Piedmonteſe ſilk being, on account of its fineneſs and ſtrength, eſteemed the beſt in Italy. The Piedmonteſe gentry breed vaſt numbers of ſilk-worms under the care of their tenants, who have the eggs and mulberry leaves delivered to them, and in return they give half the ſilk to their maſters. This principality comprehends eleven ſmall provinces: Piedmont proper, the valleys between Franee and Italy, the valley of Saluza, the county of Nice, the marquiſate of Suſa, the duchy of Aoſt, the Canaveſe, the lordſhip of Vetſail, Piedmont. ſail, the county of Aſt, and the Langes. It was formerly a part of Lombardy, but now belongs to the king of Sardinia, and lies at the foot of the Alps, which ſeparate France from Italy. It contains many high mountains, among which there are rich and fruitful valleys, as pleaſant and populous as any part of Italy. In the mountains are mines of ſeveral kinds, and the foreſts afford a great deal of curious game, among which the *tumor* is an uſeful animal. "The mules (ſays Mr Watkins) are very fine in this country; but the inhabitants have other beaſts, or rather monſters which they find very ſerviceable, though vicious and obſtinate. Theſe are produced by a cow and an aſs, or mare and bull, and called *jumarres* or *gimerri* (A). I cannot ſay that I have ever ſeen any of them, but I am told they are very common."

The Piedmonteſe are ſaid to be more intelligent than the Savoyards, but leſs ſincere. Some authors repreſent them as lively, artful, and witty, the inhabitants of the mountain of Aoſta excepted, who are farther diſtinguiſhed by large wens, as even their horſes, dogs, and other animals. Mr Baretti, however, in his *Account of Italy*, vol. ii. p. 116. gives the following account of them. "One of the chief qualities (ſays he), which diſtinguiſh the Piedmonteſe from all other Italians, is their want of cheerfulneſs. Piedmont never produced a ſingle good poet, as far as the records of the country can go, whereas there is no other province of Italy but what can boaſt of ſome poet ancient or modern; and yet the Piedmonteſe are not deficient in ſeveral branches of learning, and ſome of them have ſucceeded tolerably well in civil law, phyſic, and the mathematics. It is likewiſe obſerved of this people, that none of them ever attained to any degree of excellence in the polite arts, and it is but lately that they can boaſt of a painter, Cavaliero Bomente; a ſtatuary, Signor Lodetto; and ſome architects, Conte Alfieri, Signor Borra, and others, who yet, to ſay the truth, are far inferior to numberleſs artiſts produced by the other provinces of Italy. They have, on the other hand, greatly advanced when conſidered as ſoldiers; though their troops have never been very numerous, every body converſant in hiſtory knows the brave ſtand they made for ſome centuries paſt againſt the French, Spaniards, and Germans, whenever they have been invaded by theſe nations. The ſkill of the Piedmonteſe in fortification is likewiſe very great, and their Bertolas and Pintos have ſhown as much genius as the Vaubans and Cohorns, in rendering impregnable ſeveral places which inferior engineers would only have made ſecure."

Payne's Geog. vol. ii.

The chief trade of this principality conſiſts in hemp and ſilk. Indeed, ſo great is their trade in raw ſilk, that the Engliſh alone have purchaſed to the value of 200,000 lib. in a year. The ſilk worm thrives ſo well, that many peaſants make above (B) 100 lib. of ſilk annually; and it is not only abundant, but univerſally known to be ſtronger and finer than any in Italy. The land owners divide the profit with their tenants. The Piedmonteſe workmen, however, are ſaid to want expertneſs, though they finiſh their work equally well with thoſe of other nations. The high duty and land-carriage on mules likewiſe tend to leſſen the value of this trade. They have beſides corn, rice, wine, fruits, flax, and cattle.

Piedmont, Pienes.

In the valleys of Lucerne, Peyrouſe, and St Martin, which have always belonged to Piedmont, live the celebrated Waldenſes or Vaudois, a name which ſignifies *people of the valleys*. Theſe have rendered themſelves famous in hiſtory for their diſſent from the Romiſh church long before the time of Luther and Calvin, and for the perſecutions they have ſuffered on that account; but ſince the year 1730 they have not been openly moleſted for their religion, but, in order to ſuppreſs them by degrees, a popiſh church has been built in every pariſh. They are heavily taxed, and labour under great oppreſſions. The number of people in theſe valleys ſcarce at preſent exceeds 10,000, of which 1000 are Catholics. The chief river of Piedmont is the Po, which flows out of Mount Viſo. The river Seſia, the Doria, Baltea, the ancient Druria, the Tenaro, and ſeveral others, run into it. The Var, anciently called the Varus, riſes in the county of Nice, and after watering it empties itſelf into the Mediterranean. The language of the Piedmonteſe is a mixture of French and Italian. In this country are about 50 earldoms, 15 marquiſates, a multitude of lordſhips, and 20 abbeys. Though the country be entirely popiſh, except ſome valleys inhabited by the Waldenſes, the king reſerves to himſelf the greateſt part of the power in church affairs, which in many other places is given up to the pope, and the conſtitution *unigenitus* is here univerſally oppoſed. Towards the end of the 17th century, the French king perſuaded the duke of Savoy to drive them out of the country; in conſequence of which 200,000 of them retired to Germany, England, and Holland, and yet they are not all extirpated, though, as we have obſerved, they are obliged to have a Roman Catholic church in every pariſh.

Turin, formerly the reſidence of the king of Sardinia, to whom this principality belonged, is the chief city. See TURIN. The number of inhabitants, Mr Watkins ſays, in Piedmont and Savoy, amount to 2,695,727 ſouls, of which Turin contains about 77,000. Piedmont, as well as the reſt of Italy, few of our readers need be informed, is now ſubject to the overgrown power of France.

PIENES, a ſmall iſland of Japan, oppoſite to the harbour of Saccai, is famed not only for the beauty of its walks, to which crowds of people reſort from the city, but for a deity worſhipped there, to which vaſt numbers of perſons devote themſelves. They go from his temple to the ſea ſide, where they enter into a boat provided

(A) Theſe equivocal animals, however, if we may ſo term them, are ſo generally mentioned by travellers in this part of Europe, that we have no doubt of their exiſtence, or of their being found hardy and ſerviceable as labourers.

(B) Each pound is valued in Piedmont at 18s. The little village of La Tour, in the valley of Lucerne, makes above 50,000 lb. annually, and the exports every year to the ſingle city of Lyons amount to more than 160,000l. Sterling.

provided for the purpose; then, launching into the deep, they throw themselves overboard, loaded with stones, and sink to the bottom. The temple of that deity, which is called Canon, is very large and lofty, and so are many others in the city itself; one in particular, dedicated to the gods of other countries, is thought the finest in the whole empire.

PIEPOUDRE, Court of, the lowest, and at the same time the most expeditious, court of justice known to the law of England. It is called piepoudre, (*curia pedis pulverizati*), from the dusty feet of the suitors; or, according to Sir Edward Coke, because justice is there done as speedily as dust can fall from the foot: Upon the same principle that justice among the Jews was administered in the gate of the city, that the proceedings might be the more speedy, as well as public. But the etymology given us by a learned modern writer is much more ingenious and satisfactory; it being derived, according to him, from *pied puldreaux*, " a pedlar," in old French, and therefore signifying the court of such petty chapmen as resort to fairs or markets. It is a court of record incident to every fair and market; of which the steward of him who owns or has the toll of the market is the judge. It was instituted to administer justice for all commercial injuries done in that very fair or market, and not in any preceding one. So that the injury must be done, complained of, heard, and determined, within the compass of one and the same day, unless the fair continues longer. The court hath cognizance of all matters of contract that can possibly arise within the precinct of that fair or market; and the plaintiff must make oath that the cause of an action arose there. From this court a writ of error lies, in the nature of an appeal, to the courts at Westminster. The reason of its institution seems to have been, to do justice expeditiously among the variety of persons that resort from distant places to a fair or market; since it is probable, that no other inferior court might be able to serve its process, or execute its judgements, on both or perhaps either of the parties; and therefore, unless this court had been erected, the complaint must necessarily have resorted even in the first instance to some superior judicature.

PIER, in building, denotes a mass of stone, &c. opposed by way of fortress to the force of the sea, or a great river, for the security of ships that lie at harbour in any haven.

Piers of a Bridge. See Bridge.

PIERCEA. See Rivinia.

PIERIA, in *Ancient Geography*, a district of Macedonia, contained between the mouths of the rivers Ludias and Peneus; extended by Strabo beyond the Ludias, to the river Axios on the north, and on the south no farther than the Aliacmon, along the west side of the Sinus Thermaicus.—Another *Pieria* of Syria, the north part of Seleucia, or the *Antiochena*, situated on the Sinus Issicus, and lying next Cilicia to the north-west.

PIERIDES, in fabulous history, the daughters of Pierus a Macedonian prince, presuming to dispute with the muses for the prize of poetry, were turned into magpies. The name of *Pierides* was also given to the muses, from Mount Pieris in Thessaly, which was consecrated to them; or, according to others, from Pieris, a Thessalian poet, who was the first who sacrificed to them. See Pieris.

PIERINO del Vaga, an eminent Italian painter, born of poor parents in Tuscany, about the year 1500. He was placed apprentice with a grocer in Florence, and got some instructions from the painters to whom he was sent with colours and pencils; but a painter named *Vaga* taking him to Rome, he was called *Del Vaga*, from living with him, his real name being *Buanacorsi*. He studied anatomy with the sciences necessary for his profession; and had somewhat of every thing that was good in his compositions. After Raphael's death, he joined with Julio Romano and Francisco Penni to finish the works in the Vatican which were left imperfect by their common master; and to confirm their friendship married Penni's sister. He gained the highest reputation by his performances in the palace of Prince Doria at Genoa: but the multiplicity of his business, and the vivacity of his imagination, drained his spirits in the flower of his age; for he died in the year 1547. Of all Raphael's disciples, Pierino kept the character of his master longest, i. e. his exterior character and manner of designing; for he fell very short of the fineness of Raphael's thinking. He had a particular genius for the decoration of places according to their customs. His invention in that kind of painting was full of ingenuity; grace and order are everywhere to be met with, and his dispositions, which are ordinary in his pictures, are wonderful in his ornaments: some of these he has made little, and some great, and placed them both with so much art, that they set off one another by comparison and contrast. His figures are disposed and designed according to Raphael's gusto; and if Raphael gave him at first some slight sketches of ornaments, as he did to Giovanni d'Udine, he executed them to admiration. The tapestries of the seven planets, in seven pieces, which Pierino designed for Diana de Poitiers, and which were, when De Piles wrote, with Monsieur the first president at Paris, shows sufficiently what he was, and that the above character does not exceed the truth.

PIERIS, in *Ancient Geography*, a mountain which is thought to have given name to Pieria of Macedonia; taking its name from Pierus a poet, who was the first that sacrificed to the Muses, thence called *Pierides*, if credit may be given to an ancient scholiast on Juvenal.

PIERRE d'automne is a French name, translated from the Chinese, of a medicinal stone, celebrated in the east for curing all disorders of the lungs. Many imagine it had its name of the autumn-stone from its being only to be made at that season of the year; but it may certainly be made equally at all times. The Chinese chemists refer the various parts of the body to the several seasons of the year, and thus they refer the lungs to autumn. This is evident in their writings, and thus the stone for diseases of the lungs came to be called *autumn-stone*. Is is prepared as follows: They put 30 pints of the urine of a strong and healthy young man into a large iron pot, and set it over a gentle fire. When it begins to boil, they add to it, drop by drop, about a large tea-cup-full of rape oil. They then leave it on the fire till the whole is evaporated to a thick substance like black mud. It is then taken out of the pot, and

and laid on a flat iron to dry, so that it may be powdered very fine. This powder is moistened with fresh oil, and the mass is put into a double crucible, surrounded with coals, where it stands till it be thoroughly dried again. This is again powdered, and put into a china vessel, which being covered with silk cloth and a double paper, they pour on it boiling water, which makes its way, drop by drop, through these coverings, till so much is got in as is sufficient to reduce it to a paste. This paste is well mixed together in the vessel it is kept in, and this is put into a vessel of water, and the whole set over the fire. The matter thus becomes again dried in *balneo mariæ*, and is then finished. *Observ. sur les Cout. de l'Asie*, p. 258.

Pierre, *St*, is a large river in North America, scarcely inferior to the Rhine or the Danube, and navigable almost to its source. Together with many other large streams, it falls into the great river Mississippi.

Pierre, *St*, or *St Peter's*, the capital of Martinico, was built in 1665, in order to overawe the mutineers of the island who rebelled against its proprietors, the second West India company, who were at the same time the proprietors of all the French Antilles. It is situated on the western side of the island. The town extends along the shore, and a battery that commands the road is erected on the west side, which is washed by the river Royolan, or St Peter. The town is divided into three wards; the middle, which is properly St Peter's, begins at the fort, and runs westward to the battery of St Nicholas. Under the walls of the second ward ships at anchor ride more securely than under the fort, on which account this ward is called the *Anchorage*. The third ward, called the *Gallery*, extends along the sea side from Fort St Peter to the Jesuits River, and is the most populous part of the city. The houses of St Peter's ward are neat, commodious, and elegant, particularly those of the governor of the island, the intendant, and the other officers. The parish church of St Peter is a magnificent stone building which belonged to the Jesuits, with a noble front of the Doric order. The church of the Anchorage, which belongs to the Jacobine friars, is likewise of stone. It is a place of considerable trade, and is built with tolerable regularity. The houses are mostly constructed of a gray pumice-stone or lava, which is found on the strand; and the high-street is, according to Dr Isert, above an English mile in length. It is supposed to contain about 2000 houses, and 30,000 inhabitants, including negroes. St Pierre, with the whole of the flourishing island of Martinico, was taken from the French in the month of March 1794, by the British troops: 125 vessels loaded with the produce of the island, and of great value, were captured, 71 of which were in the harbour of St Pierre.

PIETISTS, a religious sect, sprung up among the Protestants of Germany, seeming to be a kind of mean between the Quakers of England and the Quietists of the Romish church. They despise all sorts of ecclesiastical polity, all school theology, and all forms and ceremonies, and give themselves up to contemplation and the mystic theology. Many gross errors are charged on the Pietists, in a book entitled *Manipulus Observationum Antipietisticarum;* but they have much of the air of polemical exaggeration, and are certainly not at all just. Indeed there are Pietists of various kinds: Some running into gross illusions, and carrying their errors to the overturning of a great part of the Christian doctrine, while others are only visionaries; and others are very honest and good, though perhaps misguided, people. They have been disgusted with the coldness and formality of other churches, and have thence become charmed with the fervent piety of the Pietists, and attached to their party. without giving into the grossest of their errors. See *Mosheim's Eccl. History*, vol. iv. p. 454.

Pietists, otherwise called the *Brethren and Sisters of the Pious and Christian Schools*, a society formed in the year 1678 by Nicholas Barre, and obliged by their engagements to devote themselves to the education of poor children of both sexes.

PIETOLA, anciently called *Andes*, is a place within two Italian miles of Mantua, famous for being the birthplace of Virgil.

PIETY, is a virtue which denotes veneration for the Deity, and love and tenderness to our friends. This distinguished virtue, like many others, received among the Romans divine honours, and was made one of their gods. Acilius Glabrio first erected a temple to this divinity, which he did upon the spot on which a woman had fed with her own milk her aged father, who had been imprisoned by order of the senate, and deprived of all aliments. The story is well known, and is given at length in authors which are in the hands of every schoolboy. See *Cicero de div.* 1. and *Valerius Maximus*, v. c. 4. and our article *FILIAL Piety*.

If piety was thus practised and thus honoured in Heathen antiquity, it surely ought not to be less so, among Christians, to whom its nature is better defined, and to the practice of which they have motives of greater cogency. A learned and elegant writer has said that the want of piety arises from the want of sensibility; and his observations and arguments are so just and so well expressed, that we cannot do better than transcribe them.

"It appears to me (says Dr Knox), that the mind of man, when it is free from natural defects and acquired corruption, feels no less a tendency to the indulgence of devotion than to virtuous love, or to any other of the more refined and elevated affections. But debauchery and excess contribute greatly to destroy all the susceptible delicacy with which nature usually furnishes the heart; and, in the general extinction of our better qualities, it is no wonder that so pure a sentiment as that of piety should be one of the first to expire.

"It is certain that the understanding may be improved in a knowledge of the world, and in the arts of succeeding in it, while the heart, or whatever constitutes the seat of the moral and sentimental feelings, is gradually receding from its proper and original perfection. Indeed experience seems to evince, that it is hardly possible to arrive at the character of a complete man of the world, without losing many of the most valuable sentiments of uncorrupted nature. A complete man of the world is an artificial being; he has discarded many of the native and laudable tendencies of his mind, and adopted a new system of objects and propensities of his own creation. These are commonly gross, coarse, sordid, selfish, and sensual. All, or either of these attributes, tend directly to blunt the sense of every thing liberal, enlarged, disinterested; of every thing which participates more of an intellectual than of a sensual nature. When the heart is tied down to the earth by lust and avarice, it is not extraordinary that the eye should be seldom lifted up to heaven. To the man who spends his Sunday (because he thinks the day fit for little else) in the counting-house, in travelling, in the tavern, or in the brothel, those who go to church appear as fools, and the business they go upon as nonsense. He is callous to the feelings of devotion; but he is tremblingly alive to all that gratifies his senses or promotes his interest.

"It has been remarked of those writers who have attacked Christianity, and represented all religions merely as diversified modes of superstition, that they were indeed, for the most part, men of a metaphysical and a disputatious turn of mind, but usually little distinguished for benignity and generosity. There was, amidst all their pretensions to logical sagacity, a cloudiness of ideas, and a coldness of heart, which rendered them very unfit judges on a question in which the heart is chiefly interested; in which the language of nature is more expressive and convincing, than all the dreary subtleties of the dismal metaphysicians. Even the reasoning faculty, on which we so greatly value ourselves, may be perverted by excessive refinement; and there is an abstruse, but vain and foolish philosophy, which philosophizes us out of the noblest parts of our noble nature. One of those parts of us is our instinctive sense of religion, of which not one of those brutes which the philosophers most admire, and to whose rank they wish to reduce us, is found in the slightest degree to participate.

"Such philosophers may be called, in a double sense, the enemies of mankind. They not only endeavour to entice man from his duty, but to rob him of a most exalted and natural pleasure. Such, surely, is the pleasure of devotion. For when the soul rises above this little orb, and pours its adoration at the throne of celestial majesty, the holy fervour which it feels is itself a rapturous delight. Neither is this a declamatory representation, but a truth felt and acknowledged by all the sons of men; except those who have been defective in sensibility, or who hoped to gratify the pride or the malignity of their hearts by singular and pernicious speculation.

"Indeed all disputatious, controversial, and metaphysical writings on the subject of religion, are unfavourable to genuine piety. We do not find that the most renowned polemics in the church militant were at all more attentive than others to the common offices of religion, or that they were actuated by any peculiar degree of devotion. The truth is, their religion centered in their heads, whereas its natural region is the heart. The heart! confined, alas! in colleges or libraries, unacquainted with all the tender charities of husband, father, brother, friend; some of them have almost forgotten that they possess a heart. It has long ceased to beat with the pulsations of love and sympathy, and has been engrossed by pride on conquering an adversary in the syllogistic combat, or by impotent anger on a defeat. With such habits, and so defective a system of feelings, can we expect that a doctor of the Sorbonne, or the disputing professor of divinity, should ever feel the pure flame of piety that glowed in the bosoms of Mrs Rowe, Mrs Talbot, or Mr Nelson?

"It is however certain, that a devotional taste and habit are very desirable in themselves, exclusive of their effects in meliorating the morals and disposition, and promoting present and future felicity. They add dignity, pleasure, and security to any age: but to old age they are the most becoming grace, the most substantial support, and the sweetest comfort. In order to preserve them, it will be necessary to preserve our sensibility; and nothing will contribute so much to this purpose as a life of temperance, innocence, and simplicity."

Of piety, as it denotes love and tenderness to our friends, there have been many distinguished instances both in ancient and modern times. See *FILIAL Piety*, *FRATERNAL* and *PARENTAL Affection*, &c.

The following example of filial piety in China, taken from P. Du Halde's description of that country, will not we trust be disagreeable to our readers. "In the commencement of the dynasty of the Tang, Lou-tao-tsong, who was disaffected to the government, being accused of a fault, which touched his life, obtained leave from those who had him in custody, to perform the duties of the Tao to one of his deceased friends. He managed matters so well, that giving his keepers the slip, he fled to the house of Lou Nan-kin, with whom he had a friendship, and there hid himself. Lou Nan-kin, notwithstanding the strict search that was made, and the severity of the court against those who conceal prisoners that have escaped, would not betray his friend. However, the thing coming to be discovered, Lou Nan-kin was imprisoned; and they were just on the point of proceeding against him, when his younger brother presenting himself before the judge, *It is I, Sir*, said he, *who have hidden the prisoner; it is I who ought to die, and not my elder brother*. The eldest maintained, on the contrary, that his younger brother accused himself wrongfully, and was not at all culpable. The judge, who was a person of great sagacity, sifted both parties so effectually, that he not only discovered that the younger brother was innocent, but even made him confess it himself: *It is true, Sir*, said the younger all in tears, *I have accused myself falsely; but I have very strong reasons for so doing. My mother has been dead for some time, and her corpse is not yet buried; I have a sister also who is marriageable, but is not yet disposed of: these things which my brother is capable of managing, I am not, and therefore desire to die in his stead. Vouchsafe to admit my testimony*. The commissioner gave an account of the whole affair to the court, and the emperor at his solicitation pardoned the criminal."

PIG, see SUS, } MAMMALIA *Index*.
Guinea-PIG, see MUS, }

PIG of lead, the eighth part of a fother, amounting to 250 pounds weight.

PIGANIOL DE LA FORCE, JOHN AYMAR DE, a native of Auvergne, of a noble family, applied himself with ardour to the study of geography and of the history of France. With the view of improving himself in this study, he travelled into different provinces; and, in the course of his travels, made some important observations on the natural history, the commerce, the civil and ecclesiastical government of each province. These observations were of great use to him in compiling the works he has left behind him, of which the chief are, 1. An Historical and Geographical Description of France; the largest edition of which is that of 1753, in 15 vols. 12mo. It is the best work which has hitherto appeared upon that subject, though it contains a great number of inaccuracies and even errors. 2. A Description of Paris, in 10 vols. 12mo; a work equally entertaining and instructive, and much more complete than the description given by Germain Brice: besides, it is written with an elegant simplicity. He published an abridgement of it in 2 vols. 12mo.

Pigeon.

12mo. 3. A Defcription of the Caftle and Park of Verfailles, Marly, &c. in 2 vols. 12mo: it is very amufing, and pretty well executed. Piganiol had alfo a concern with Abbé Nadal in the journal of Trevoux. He died at Paris in February 1753, at ths age of 80 years. This learned man was as much to be refpected for his manners as for his talents. To a profound and varied knowledge he united great probity and honour, and all the politenefs of a courtier.

PIGEON, fee COLUMBA, ORNITHOLOGY *Index*.

PIGEON-Houfe is a houfe erected full of holes within, for the keeping, breeding, &c. of pigeons, otherwife called a *dove-cot*.

Any lord of manor may build a pigeon-houfe on his land, but a tenant cannot do it without the lord's licence. When perfons fhoot at or kill pigeons within a certain diftance of the pigeon-houfe, they are liable to pay a forfeiture.

In order to erect a pigeon-houfe to advantage, it will be neceffary, in the firft place, to pitch upon a convenient fituation; of which none is more proper than the middle of a fpacious court-yard, becaufe pigeons are naturally of a timorous difpofition, and the leaft noife they hear frightens them. With regard to the fize of the pigeon-houfe, it muft depend entirely upon the number of birds intended to be kept; but it is better to have it too large than too little; and as to its form, the round fhould be preferred to the fquare ones; becaufe rats cannot fo eafily come at them in the former as in the latter. It is alfo much more commodious; becaufe you may, by means of a ladder turning upon an axis, eafily vifit all the nefts in the houfe, without the leaft difficulty; which cannot fo eafily be done in a fquare houfe. In order to hinder rats from climbing up the outfide of the pigeon-houfe, the wall fhould be covered with tin plates to a certain height, about a foot and a half will be fufficient; but they fhould project out three or four inches at the top, to prevent their clambering any higher.

The pigeon-houfe fhould be placed at no great diftance from water, that the pigeons may carry it to their young ones; and their carrying it in their bills will warm it, and render it more wholefome in cold weather. The boards that cover the pigeon-houfe fhould be well joined together, fo that no rain may penetrate through it: and the whole building fhould be covered with hard plafter, and white-wafhed within and without, white being the moft pleafing colour to pigeons. There muft be no window, or other opening in the pigeon-houfe to the eaftward; thefe fhould always face the fouth, for pigeons are very fond of the fun, efpecially in winter.

The nefts or covers in a pigeon-houfe fhould confift of fquare holes made in the walls, of a fize fufficient to admit the cock and hen to ftand in them. The firft range of thefe nefts fhould not be lefs than four feet from the ground, that the wall underneath being fmooth, the rats may not be able to reach them. Thefe nefts fhould be placed in quincunx order, and not directly over one another. Nor muft they be continued any higher than within three feet of the top of the wall: and the upper row fhould be covered with a board projecting a confiderable diftance from the wall, for fear the rats fhould find means to climb the outfide of the houfe.

M. Duhamel thinks that pigeons neither feed upon the green corn, nor have bills ftrong enough to fearch for its feeds in the earth; but only pick up the grains that are not covered, which would infallibly become the prey of other animals, or be dried up by the fun. "From the time of the fprouting of the corn, fays he, pigeons live chiefly upon the feeds of wild uncultivated plants, and therefore leffen confiderably the quantity of weeds that would otherwife fpring up; as will appear from a juft eftimate of the quantity of grain neceffary to feed all the pigeons of a well-ftocked dove-houfe." But Mr Worlidge and Mr Lifle allege facts in fupport of the contrary opinion. The latter relates, that a farmer in his neighbourhood affured him he had known an acre fowed with peafe, and rain coming on fo that they could not be harrowed in, every pea was fetched away in half a day's time by pigeons: and the former fays, "It is to be obferved, that where the flight of pigeons falls, there they fill themfelves and away, and return again where they firft rofe, and fo proceed over a whole piece of ground, if they like it. Although you cannot perceive any grain above the ground, they know how to find it. I have feen them lie fo much upon a piece of about two or three acres fown with peafe, that they devoured at leaft three parts in four of the feed, which, I am fure, could not be all above the furface of the ground. That their fmelling is their principal director, I have obferved; having fown a fmall plat of peafe in my garden, near a pigeon-houfe, and covered them fo well that not a pea appeared above ground. In a few days, a parcel of pigeons were hard at work in difcovering this hidden treafure; and in a few days more I had not above two or three peas left out of about two quarts that were planted; for what they could not find before, they found when the buds appeared, notwithftanding they were hoed in, and well covered. Their fmelling alone directed them, as I fuppofed, becaufe they followed the ranges exactly. The injury they do at harveft on the peafe, vetches, &c. is fuch that we may rank them among the greateft enemies the poor hufbandman meets withal; and the greater, becaufe he may not erect a pigeon-houfe, whereby to have a fhare of his own fpoils; none but the rich being allowed this privilege, and fo fevere a law being alfo made to protect thefe winged thieves, that a man cannot encounter them, even in defence of his own property. You have therefore no remedy againft them, but to affright them away by noifes or fuch like. You may, indeed, fhoot at them; but you muft not kill them; or you may, if you can, take them in a net, cut off their tails, and let them go; by which means you will impound them: for when they are in their houfes, they cannot bolt or fly out of the tops of them, but by the ftrength of their tails; after the thus weakening of which, they remain prifoners at home."

Mr Worlidge's impounding the pigeons reminds us of a humorous ftory of a gentleman, who, upon a neighbouring farmer's complaining to him, that his pigeons were a great nuifance to his land, and did fad mifchief to his corn, replied jokingly, Pound them, if you catch them trefpaffing. The farmer, improving the hint, fteeped a parcel of peafe in an infufion of *coculus indicus*, or fome other intoxicating drug, and ftrewed them upon his grounds. The pigeons fwallowed them, and foon remained motionlefs on the field: upon which the farmer threw a net over them, inclofed them in it, and carried them to an empty barn, from whence he ſent the gentleman word that he had followed his directions with regard to the pounding of his pigeons, and deſired him to come and releaſe them.

Carrier-PIGEON. See *CARRIER-Pigeon* and COLUMBA, ORNITHOLOGY *Index.*

PIGEON, *Peter Charles Francis*, curate of St Peter du Regard, in the dioceſe of Bayeux, was one of the prieſts lately belonging to the king's houſe at Wincheſter. He was born in Lower Normandy, of honeſt and virtuous parents, and of a decent fortune. His inclinations early led him to embrace the eccleſiaſtical ſtate, from which neither the ſolicitations of his friends, nor the proſpect of a more ample fortune on the death of his elder brother, could withdraw him. Several of his ſchoolfellows and maſters, who are now reſident in the king's houſe at Wincheſter, bear the moſt ample teſtimony to his aſſiduity, regularity, piety, and the ſweetneſs of his diſpoſition, during the whole courſe of his education. The ſweetneſs of temper, in particular, was ſo remarkable, and ſo clearly depicted on his countenance, as to have gained him the eſteem and affection of ſuch of the inhabitants of Wincheſter as by any means had become acquainted with him. He was ſeven years employed in quality of vicar, or, as we ſhould call it, *curate*, of a large pariſh in the dioceſe of Seez, where his virtues and talents had ample ſcope for exertion. His practice was to riſe at five o'clock every morning, and to ſpend the whole time till noon (the uſual time of dining for perſons in his ſtation) in prayer and ſtudy. The reſt of the day, till evening, he devoted to viſiting the ſick, and other exterior duties of his function. In 1789, the year of the French revolution, M. Pigeon was promoted to a curacy, or rather a rectory, in the dioceſe of Bayeux, called the *pariſh of St Peter du Regard*, near the town of Condè ſur Noereau. It was eaſy for him to gain the good-will and the protection of his pariſhioners; but a Jacobin club in the above-mentioned town ſeemed to have no other ſubject to deliberate upon than the various ways of haraſſing and perſecuting M. Pigeon and certain other prieſts in the neighbourhood, who had from motives of conſcience refuſed the famous civic oath. It would be tedious to relate the many cruelties which were at different times exerciſed upon him, and the imminent danger of loſing his life to which he was expoſed, by the blows that were inflicted on him, by his being thrown into water, and being obliged to wander in woods and other ſolitary places, without any food or place to lay his head, in order to avoid his perſecutors. We may form ſome judgement of the ſpirit of his perſecutors from the following circumſtance. Being diſappointed on a particular occaſion in the ſearch they were making after M. Pigeon, with the view of amuſing themſelves with his ſufferings, they made themſelves amends by ſeizing his mother, a reſpectable lady of 74 years of age, and his two ſiſters, whom they placed upon aſſes with their faces turned backwards, obliging them in deriſion to hold the tails of theſe animals. Thus they were conducted in pain and ignominy throughout the whole town of Condè, for no other alleged crime except being the neareſt relations of M. Pigeon. At length the decree for tranſporting all the eccleſiaſtics arrived; and this gentleman, with ſeveral others, after having been ſtripped of all their money, was ſhipped from Port Beſſin, and landed at Portſmouth, where he was ſhortly after received into the eſtabliſhment at Foxton, and, upon that being diſſolved in order to make room for priſoners of war, into the king's houſe at Wincheſter. Being of a ſtudious turn, he was accuſtomed, as many of his brethren alſo were, to betake himſelf to the neighbouring lanes and thickets for the ſake of greater ſolitude. With this view having, about ten o'clock in the morning, Aug. 28. 1793, retired to a certain little valley, on the north-eaſt ſide of a place called *Oram's Arbour*, the ſame place where the county elections for Hampſhire are held, he was there found, between three and four o'clock in the afternoon, murdered, with the upper part of his ſkull abſolutely broken from the lower part, and a large hedge-ſtake, covered with blood, lying by him, as were the papers on which he had been tranſcribing a manuſcript ſermon, with the hearing of which he had been much edified, and the ſermon itſelf which he was copying, together with his pen, imbrued in blood. His watch was carried away, though part of the chain, which had by ſome means been broken, was left behind. He was writing the word *paradiſe*, the laſt letters of which remained unwritten when the fatal blow was given him, which appears evidently to have been diſcharged upon him from a gap in a hedge which was immediately behind him. At firſt the ſuſpicion of this cruel murder fell upon the French democrats, who, to the number of 200, are priſoners of war, at the neighbouring town of Alresford, as one of that number, who had broken his parole, had, about three weeks before, been taken up in Wincheſter, and both there and at Alresford had repeatedly threatened to murder his uncle, a prieſt, whom he underſtood to be then at Wincheſter, not without fervent wiſhes of having it in his power to murder the whole eſtabliſhment, conſiſting of more than 600 perſons. However, as no French priſoner was ſeen that day in the neighbourhood of Wincheſter, as none of them were known to have left Alresford, it is evidently reaſonable to acquieſce in the verdict of the coroner; namely, that the murder was committed by a perſon or perſons unknown. The moſt noble marquis of Buckingham, whoſe munificence and kindneſs to thoſe conſcientious exiles, the emigrant French clergy, can only be conceived by thoſe who have been witneſſes of the ſame, with the truly reſpectable corps of the Buckinghamſhire militia, then quartered at Wincheſter, joined in paying the laſt mark of reſpect to the unfortunate deceaſed, by attending his funeral, which was performed at the Roman Catholic burying-ground, called *St James's*, near the ſaid city, on Saturday, Aug. 29. He was juſt 38 years of age when he was murdered.

PIGMENTS, preparations uſed by painters, dyers, &c. to impart colours to bodies, or to imitate particular colours. See *COLOUR-Making*, and DYEING.

PIGNEROL is a town of Italy in the province of Piedmont, in E. Long. 7. 15. N. Lat. 44. 45. ſituated on the river Chizon, 10 miles ſouth-weſt of Turin, at the foot of the Alps, and the confines of Dauphiny. The town is ſmall, but populous, and extremely well fortified by the king of Sardinia, ſince the treaty of Utrecht. It is defended by a citadel, on the top of the mountain near which is the caſtle of Perouſe, which was built at the entrance of the valley of that name.

PIGNUT, or *Earthnut.* See BUNIUM, BOTANY *Index.*

PIGUS,

PIGUS, in *Ichthyology*, is the name of a ſpecies of leather-mouthed fiſh, very much reſembling the nature of the common carp; being of the ſame ſhape and ſize, and its eyes, fins, and fleſhy palate, exactly the ſame; from the gills to the tail there is a crooked dotted line; the back and ſides are bluiſh, and the belly reddiſh. It is covered with large ſcales; from the middle of each of which there riſes a fine pellucid prickle, which is very ſharp. It is an excellent fiſh for the table, being perhaps preferable to the carp; and it is in ſeaſon in the months of March and April. It is caught in lakes in ſome parts of Italy, and is mentioned by Pliny, though without a name. Artedi ſays it is a ſpecies of cyprinus, and he calls it the *cyprinus*, called *piclo* and *pigus*.

PI-HAHIROTH, (Moſes); underſtood to be a mouth or narrow paſs between two mountains, called *Chiroth*, or *Eiroth*, and lying not far from the bottom of the weſtern coaſt of the Arabian gulf; before which mouth the children of Iſrael encamped, juſt before their entering the Red ſea, (Wells).

PIISSKER, in *Ichthyology*, is a fiſh of the muſtela kind, commonly called the *foſſile muſtela*, or *foſſile fiſh*. This fiſh is generally found as long as an ordinary man's hand is broad, and as thick as the finger; but it ſometimes grows much longer: the back is of gray with a number of ſpots and tranſverſe ſtreaks, partly black and partly blue; the belly is yellow, and ſpotted with red, white, and black; the white are the larger, the others look as if they were made with the point of a needle; and there is on each of the ſides a longitudinal black and white line. There are ſome fleſhy excreſcences at the mouth, which are expanded in ſwimming; and when out of the water, they are contracted. Theſe fiſhes run into caverns of the earth, in the ſides of rivers, in marſhy places, and penetrate a great way, and are often dug up at a diſtance from waters. Often, when the waters of brooks and rivers ſwell beyond their banks, and again cover them, they make their way out of the earth into the water; and when it deſerts them, they are often left in vaſt numbers upon the ground, and become a prey to ſwine. It is thought to be much of the ſame kind with the fiſgum fiſh; and it is indeed poſſible that the pæcilia of Schonefeldt is the ſame.

PIKE. See Esox, Ichthyology *Index*.

The pike never ſwims in ſhoals as moſt other fiſh do, but always lies alone; and is ſo bold and ravenous, that he will ſeize upon almoſt any thing leſs than himſelf. Of the ravenous nature of this fiſh we ſhall give the following inſtances. At Rycott in Oxfordſhire, in the year 1749, in a moat ſurrounding the earl of Abingdon's ſeat, there was a jack or pike of ſuch a monſtrous ſize, that it had deſtroyed young ſwans feathers and all. An old cobb ſwan having hatched five young, one after another was loſt till four were gone. At length an under gardener ſaw the fiſh ſeize the fifth. The old one fought him with their beak, and with the aſſiſtance of the gardener, releaſed it although he had got it under water. In the year 1765 a large pike was caught in the river Ouze, which weighed upwards of 28 pounds, and was ſold for a guinea. On gutting the fiſh, a watch with a black ribbon and two ſteel ſeals were found in its ſtomach, which, by the maker's name, &c. was found to belong to a perſon who had been drowned about ſix weeks before. This fiſh breeds but once in a year, which is in March. It is found in almoſt all freſh waters; but is very different in goodneſs, according to the nature of the places where it lives. The fineſt pike are thoſe which feed in clear rivers; thoſe in ponds and meres are inferior, and the worſt of all are thoſe of the fen ditches. They are very plentiful in theſe laſt places, where the water is foul and coloured, and their food, ſuch as frogs and the like, very plentiful, but very coarſe; ſo that they grow large, but are yellowiſh and high bellied, and differ greatly from thoſe which live in the clearer waters.

The fiſhermen have two principal ways of catching the pike; by the ledger, and by the walking-bait.

The ledger-bait is fixed in one certain place, and may continue while the angler is abſent. This muſt be a live bait, a fiſh or frog: and among fiſh, the dace, roach, and gudgeon, are the beſt; of frogs, the only caution is to chooſe the largeſt and yelloweſt that can be met with. If the bait be a fiſh, the hook is to be ſtuck through the upper lip, and the line muſt be 14 yards at leaſt in length; the other end of this is to be tied to a bough of a tree, or to a ſtick driven into the ground near the pike's haunt, and all the line wound round a forked ſtick, except about half a yard. The bait will by this means keep playing ſo much under water, and the pike will ſoon lay hold of it.

If the bait be a frog, then the arming wire of the hook ſhould be put in at the mouth, and out at the ſide; and with a needle and ſome ſtrong ſilk, the hinder leg of one ſide is to be faſtened by one ſtitch to the wire-arming of the hook. The pike will ſoon ſeize this, and muſt have line enough to give him leave to get to his haunt and poach the bait.

The trolling for pike is a pleaſant method alſo of taking them: in this a dead bait ſerves, and none is ſo proper as a gudgeon.

This is to be pulled about in the water till the pike ſeizes it; and then it is to have line enough, and time to ſwallow it: the hook is ſmall for this ſport, and has a ſmooth piece of lead fixed at its end to ſink the bait; and the line is very long, and runs through a ring at the end of the rod, which muſt not be too ſlender at top.

The art of feeding pike, ſo as to make them very fat, is the giving them eels; and without this it is not to be done under a very long time; otherwiſe perch, while ſmall, and their prickly fins tender, are the beſt food for them. Bream put into a pike-pond are a very proper food: they will breed freely, and their young ones make excellent food for the pike, who will take care that they ſhall not increaſe over much. The numerous ſhoals of roaches and ruds, which are continually changing place, and often in floods get into the pike's quarters, are food for them for a long time.

Pike, when uſed to be fed by hand, will come up to the very ſhore, and take the food that is given them out of the fingers of the feeder. It is wonderful to ſee with what courage they will do this, after a while practiſing; and it is a very diverting ſight when there are ſeveral of them nearly of the ſame ſize, to ſee what ſtriving and fighting there will be for the beſt bits when they are thrown in. The moſt convenient place is near the mouth of the pond, and where there is about half a yard depth of water; for, by that means, the offal of the feedings will all lie in one place, and the deep water will

will serve for a place to retire into and rest in, and will be always clean and in order.

Carp may be fed in the same manner as pike; and though by nature a fish as remarkably shy and timorous as the pike is bold and fearless, yet by custom they will come to take their food out of the person's hand; and will, like the pike, quarrel among one another for the nicest bits.

PIKE, in *War*, an offensive weapon, consisting of a wooden shaft, 12 or 14 feet long, with a flat steel head, pointed, called the *spear*. This weapon was long in use among the infantry; but now the bayonet, which is fixed on the muzzle of the firelock, is substituted in its stead. It is still used by some of the officers of infantry, under the name of *sponton*. The Macedonian phalanx was a battalion of pikemen. See PHALANX.

PILA MARINA, or the *sea-ball*, in *Natural History*, is the name of a substance very common on the shores of the Mediterranean, and elsewhere. It is generally found in the form of a ball about the size of the balls of horse dung, and composed of a variety of fibrillæ irregularly complicated. Various conjectures have been given of its origin by different authors. John Bauhine tells us, that it consists of small hairy fibres and straws, such as are found about the sea plant called *alga vitriariorum*; but he does not ascertain what plant it owes its origin to. Imperatus imagined it consisted of the exuviæ both of vegetable and animal bodies. Mercatus is doubtful whether it be a congeries of the fibrillæ of plants, wound up into a ball by the motion of the sea water, or whether it be not the workmanship of some sort of beetle living about the sea shore, and analogous to our common dung beetle's ball, which it elaborates from dung for the reception of its progeny. Schreckius says it is composed of the filaments of some plant of the reed kind: and Welchius supposes it is composed of the pappous part of the flowers of the reed. Maurice Hoffman thinks it the excrement of the hippopotamus; and others think it that of the phoca or sea calf. Klein, who had thoroughly and minutely examined the bodies themselves, and also what authors had conjectured concerning them, thinks that they are wholly owing to, and entirely composed of, the capillaments which the leaves, growing to the woody stalk of the *alga vitriariorum*, have when they wither and decay. These leaves, in their natural state, are as thick as a wheat straw, and they are placed so thick about the tops and extremities of the stalks, that they enfold, embrace, and lie over one another; and from the middle of these clusters of leaves, and indeed from the woody substance of the plant itself, there arise several other very long, flat, smooth, and brittle leaves. These are usually four from each tuft of the other leaves; and they have ever a common vagina, which is membranaceous and very thin. This is the style of the plant, and the *pila marina* appears to be a cluster of the fibres of the leaves of this plant, which cover the whole stalk, divided into their constituent fibres; and by the motion of the waves first broken and worn into short shreds, and afterwards wound up together into a roundish or longish ball.

PILA, was a ball made in a different manner according to the different games in which it was to be used. Playing at ball was very common amongst the Romans of the first distinction, and was looked upon as a manly exercise, which contributed both to amusement and health. The pila was of four sorts: 1st, *Follis* or *balloon*; 2d, *Pila Trigonalis*; 3d, *Pila Paganica*; 4th, *Harpastum*. All these come under the general name of pila. For the manner of playing with each of them, see the articles FOLLIS, TRIGONALIS.

PILASTER, in *Architecture*. See there, N° 50, &c.

PILATE, or PONTIUS PILATE, was governor of Judea when our Lord was crucified. Of his family or country we know but little, though it is believed that he was of Rome, or at least of Italy. He was sent to govern Judea in the room of Gratus, in the year 26 or 27 of the vulgar era, and governed this province for ten years, from the 12th or 13th year of Tiberius to the 22d or 23d. He is represented both by Philo and Josephus as a man of an impetuous and obstinate temper, and as a judge who used to sell justice, and to pronounce any sentence that was desired, provided he was paid for it. The same authors make mention of his rapines, his injuries, his murders, the torments that he inflicted upon the innocent, and the persons he put to death without any form of process. Philo, in particular, describes him as a man that exercised an excessive cruelty during the whole time of his government, who disturbed the repose of Judea, and gave occasion to the troubles and revolt that followed after. St Luke (xiii. 1, 2, &c.) acquaints us, that Pilate had mingled the blood of the Galileans with their sacrifices; and that the matter having been related to Jesus Christ, he said, "Think you that these Galileans were greater sinners than other Galileans, because they suffered this calamity. I tell you nay; and if you do not repent, you shall all perish in like manner." It is unknown upon what occasion Pilate caused these Galileans to be slain in the temple while they were sacrificing; for this is the meaning of that expression of mingling their blood with their sacrifices. Some think they were disciples of Judas the Gaulonite, who taught that the Jews ought not to pay tribute to foreign princes; and that Pilate had put some of them to death even in the temple; but there is no proof of this fact. Others think that these Galileans were Samaritans, whom Pilate cut to pieces in the village of Tirataba †, as they were preparing to go up to Mount Gerizim, where a certain impostor had promised to discover treasures to them; but this event did not happen before the year 35 of the common era, and consequently two years after the death of Jesus Christ. At the time of our Saviour's passion, Pilate made some endeavours to deliver him out of the hands of the Jews. He knew they had delivered him up, and pursued his life with so much violence, only out of malice and envy (Matt. xxvii. 18.). His wife also, who had been disturbed the night before with frightful dreams, sent to tell him she desired him not to meddle in the affair of that just person (ib. 19.). He attempted to appease the wrath of the Jews, and to give them some satisfaction, by whipping Jesus Christ (John xix. 1. Matth. xxvii. 26.). He tried to take him out of their hands, by proposing to deliver him or Barabbas, on the day of the festival of the passover. Lastly, he had a mind to discharge himself from pronouncing judgement against him, by sending him to Herod king of Galilee (Luke xxiii. 7, 8.). When he saw all this would not satisfy the Jews, and that they even threatened him in some manner, saying he could be no friend to the emperor if he let him go (John xix. 12, 15.), he caused water

† *Joseph. Antiq.* lib. xviii. c. 5.

water to be brought, washed his hands before all the people, and publicly declared himself innocent of the blood of that just person (Matt. xxvii. 23, 24.); yet at the same time he delivered him up to his soldiers, that they might crucify him. This was enough to justify Jesus Christ, as Calmet observes, and to show that he held him as innocent; but it was not enough to vindicate the conscience and integrity of a judge, whose duty it was as well to assert the cause of oppressed innocence as to punish the guilty and criminal. He ordered to be put over our Saviour's cross, as it were, an abstract of his sentence, and the motive of his condemnation (John xix. 9.), *Jesus of Nazareth, king of the Jews*, which was written in Latin, Greek, and Hebrew. Some of the Jews found fault with it, and remonstrated to Pilate that he ought to have written *Jesus of Nazareth, who pretended to be king of the Jews*. But Pilate could not be prevailed with to alter it, and gave them this peremptory answer, *That what he had written he had written*.

Towards evening, he was applied to for leave to take down the bodies from the cross, that they might not continue there the following day, which was the passover and the sabbath-day (John xix. 31.). This he allowed, and granted the body of Jesus to Joseph of Arimathea, that he might pay his last duties to it, (ib. 33.). Lastly, when the priests, who had solicited the death of our Saviour, came to desire him to set a watch about the sepulchre, for fear his disciples should steal him away by night, he answered them, that they had a guard, and might place them there themselves (Matt. xxvii. 65.). This is the substance of what the gospel tells us concerning Pilate.

Justin Martyr, Tertullian, Eusebius, and after them several others both ancient and modern, assure us, that it was formerly the custom for Roman magistrates to prepare copies of all verbal processes and judicial acts which they passed in their several provinces, and to send them to the emperor. And Pilate, in compliance to this custom, having sent word to Tiberius of what had passed relating to Jesus Christ, the emperor wrote an account of it to the senate, in a manner that gave reason to judge that he thought favourably of the religion of Jesus Christ, and showed that he should be willing they would decree divine honours to him. But the senate was not of the same opinion, and so the matter was dropped. It appears by what Justin says of these acts, that the miracles of Jesus Christ were mentioned there, and even that the soldiers had divided his garments among them. Eusebius insinuates that they spoke of his resurrection and ascension. Tertullian and Justin refer to these acts with so much confidence as would make one believe they had them in their hands. However, neither Eusebius nor St Jerome, who were both inquisitive, understanding persons, nor any other author that wrote afterwards, seem to have seen them, at least not the true and original acts; for as to what we have now in great number, they are not authentic, being neither ancient nor uniform. There are also some pretended letters of Pilate to Tiberius, giving a history of our Saviour, but they are universally allowed to be spurious.

Pilate being a man that, by his excessive cruelties and rapine, had disturbed the peace of Judea during the whole time of his government, was at length deposed by Vitellius the proconsul of Syria, in the 36th year of Jesus Christ, and sent to Rome to give an account of his conduct to the emperor. But though Tiberius died before Pilate arrived at Rome, yet his successor Caligula banished him to Vienne in Gaul, where he was reduced to such extremity that he killed himself with his own hands. The evangelists call him governor, though in reality he was no more than procurator of Judea, not only because governor was a name of general use, but because Pilate in effect acted as one, by taking upon him to judge in criminal matters; as his predecessors had done, and other procurators in the small provinces of the empire where there was no proconsul, constantly did. See *Calmet's Dictionary*, *Echard's Ecclesiastical Dictionary*, and *Beausobre's Annot.*

With regard to Pilate's wife, the general tradition is, that she was named Claudia Procula or Proscula; and in relation to her dream, some are of opinion that as she had intelligence of our Lord's apprehension, and knew by his character that he was a righteous person, her imagination, being struck with these ideas, did naturally produce the dream we read of; but others think that this dream was sent providentially upon her, for the clearer manifestation of our Lord's innocence.

PILATRE DU ROZIER, *Francis*, was born at Metz the 30th of March 1756. He was first apprentice to an apothecary there, and afterwards went to Paris in quest of farther improvement. He applied himself to the study of natural history and of natural philosophy, and had already acquired some reputation, when the discovery of M. de Montgolfier had just astonished the learned world. On the 25th of October 1783, he attempted an aerial voyage with the Marquis of Arlande. He performed several other excursions in this way with brilliant success, in the presence of the royal family of France, of the king of Sweden, and of Prince Henry of Prussia. He then resolved to pass into England by means of his aerial vehicle, and for that purpose he repaired to Boulogne, whence he rose about 7 o'clock in the morning of the 15th June 1785; but in half an hour after he set out, the balloon took fire, and the aeronaut, with his companion M. Romaine, were crushed to death by the fall of that machine, which was more ingenious, perhaps, than useful *. Pilatre's social virtues and courage, which were very distinguished, heightened the regret of his friends for his loss. His merit as a chemist, and his experiments as an aeronaut, procured him some pecuniary reward, and some public appointments. He had a pension from the king, was intendant of Monsieur's cabinets of natural philosophy, chemistry, and natural history, professor of natural philosophy, a member of several academies, and principal director of Monsieur's museum.

* See *Aerostation*, N° 34.

PILCHARD, in *Ichthyology*, a fish which has a general resemblance to the herring, but differs in some essential particulars. The body of the pilchard is less compressed than that of the herring, being thicker and rounder: the nose is shorter in proportion, and turns up; the under jaw is shorter. The back is more elevated; the belly less sharp. The dorsal fin of the pilchard is placed exactly in the centre of gravity, so that when taken up by it, the body preserves an equilibrium, whereas that of the herring dips at the head. The scales of the pilchard adhere very closely, whereas those of the herring very easily drop off. The pilchard is in general less than the herring; but it is fatter, or more full of oil.

The

Pilchard, Pile.

The pilchard appears in vaſt ſhoals off the Corniſh coaſts about the middle of July, diſappearing the beginning of winter, yet ſometimes a few return again after Chriſtmas. Their winter retreat is the ſame with that of the herring, and their motives for migrating the ſame †. They affect, during ſummer, a warmer latitude; for they are not found in any quantities on any of our coaſts except thoſe of Cornwall, that is to ſay, from Fowey harbour to the Scilly iſles, between which places the ſhoals keep ſhifting for ſome weeks. The approach of the pilchard is known by much the ſame ſigns as thoſe that indicate the arrival of the herring. Perſons, called in Cornwall *huers*, are placed on the cliffs, to point to the boats ſtationed off the land the courſe of the fiſh. By the 1ſt of James I. c. 23. fiſhermen are empowered to go on the grounds of others to hue, without being liable to actions of treſpaſs, which before occaſioned frequent law-ſuits.

† See *Clupea.*

The emoluments that accrue to the inhabitants of that country are great, and are beſt expreſſed in the words of Dr W. Borlaſe, in his *Account of the Pilchard Fiſhery.* "It employs a great number of men on the ſea, training them thereby to naval affairs; employs men, women, and children, at land, in ſalting, preſſing, waſhing, and cleaning, in making boats, nets, ropes, caſks, and all the trades depending on their conſtruction and ſale. The poor is fed with the offals of the captures; the land with the refuſe of the fiſh and ſalt; the merchant finds the gains of commiſſion and honeſt commerce; the fiſherman, the gains of the fiſh. Ships are often freighted hither with ſalt, and into foreign countries with the fiſh, carrying off at the ſame time part of our tin. The uſual number of hogſheads of fiſh exported each year, for 10 years, from 1747 to 1756 incluſive, from the four ports of Fowey, Falmouth, Penzance, and St Ives, in all amounts to 29,794; ſince it appears that Fowey has exported yearly 1732 hogſheads; Falmouth, 14,631 hogſheads and two-thirds; Penzance and Mounts-Bay, 12,149 hogſheads and one-third; St Ives, 1282 hogſheads. Every hogſhead for ten years laſt paſt, together with the bounty allowed for each when exported, and the oil made out of each, has amounted, one year with another at an average, to the price of 1l. 13s. 3d.; ſo that the caſh paid for pilchards exported has, at a medium, annually amounted to the ſum of 49,532l. 10s." The numbers that are taken at one ſhooting out of the nets is amazingly great. Mr Pennaut ſays, that Dr Borlaſe aſſured him, that on the 5th of October 1767, there were at one time incloſed in St Ives's bay 7000 hogſheads, each hogſhead containing 35,000 fiſh, in all 245,000,000.

PILE, in *Heraldry*, an ordinary in form of a wedge, contracting from the chief, and terminating in a point towards the bottom of the ſhield.

PILE, among the Greeks and Romans, was a pyramid built of wood, whereon were laid the bodies of the deceaſed to be burnt. It was partly in the form of an altar, and differed in height according to the quality of the perſon to be conſumed. Probably it might originally be conſidered as an altar, on which the dead were conſumed as a burnt offering to the infernal deities. The trees made uſe of in the erection of a funeral pile were ſuch as abounded in pitch or roſin, as being moſt combuſtible; if they uſed any other wood, it was ſplit that it might the more eaſily catch fire. Round the pile were placed cypreſs boughs to hinder the noiſome ſmell. See FUNERAL.

Pile.

PILE, in *Building*, is uſed for a large ſtake rammed into the ground in the bottom of rivers, or in marſhy land, for a foundation to build upon.

PILE is alſo uſed among architects for a maſs of building.

PILE, in *Coinage*, denotes a kind of puncheon, which, in the old way of coining with the hammer, contained the arms or other figure and inſcription to be ſtruck on the coin. See COINAGE.

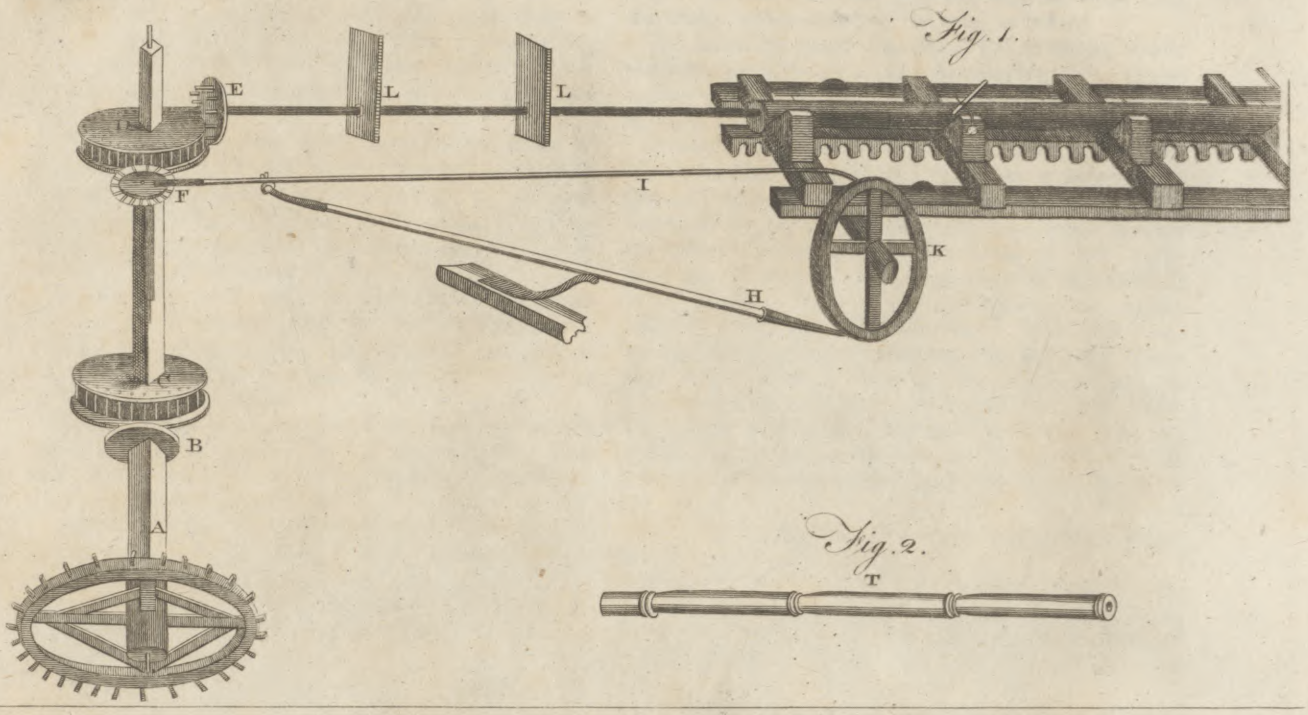
Accordingly we ſtill call the arms ſide of a piece of money the *pile*, and the head the *croſs*; becauſe in ancient coin, a croſs uſually took the place of the head in ours.

PILE-Engine, a very curious machine invented by Mr Vauloue for driving the piles of Weſtminſter-bridge. A is a great upright ſhaft or axle, on which are the great wheel B, and the drum C, turned by horſes joined to the bars S, S. The wheel B turns the trundle X, on the top of whoſe axis is the fly O, which ſerves to regulate the motion, and alſo to act againſt the horſes, and to keep them from falling when the heavy ram Q is diſcharged to drive the pile P down into the mud in the bottom of the river. The drum C is looſe upon the ſhaft A, but is locked to the wheel B by the bolt Y. On this drum the great rope HH is wound; one end of the rope being fixed to the drum, and the other to the follower G, to which it is conveyed over the pulleys I and K. In the follower G is contained the tongs F, that takes hold of the ram Q by the ſtaple R, for drawing it up. D is a ſpiral or fuſy fixed to the drum, on which is wound the ſmall rope T that goes over the pulley U, under the pulley V, and is faſtened to the top of the frame at 7. To the pulley-block V is hung the counterpoiſe W, which hinders the follower T from accelerating as it goes down to take hold of the ram; for as the follower tends to acquire velocity in its deſcent, the line T winds downwards upon the fuſy, on a larger and larger radius, by which means the counterpoiſe W acts ſtronger and ſtronger againſt it; and ſo allows it to come down with only a moderate and uniform velocity. The bolt Y locks the drum to the great wheel, being puſhed upward by the ſmall lever 2, which goes through a mortiſe in the ſhaft A, turns upon a pin in the bar 3, fixed to the great wheel B, and has a weight 4, which always tends to puſh up the bolt Y through the wheel into the drum. L is the great lever turning on the axis *m*, and reſting upon the forcing bar 5, 5, which goes through a hollow in the ſhaft A, and bears up the little lever 2.

Plate CCCCXIX.

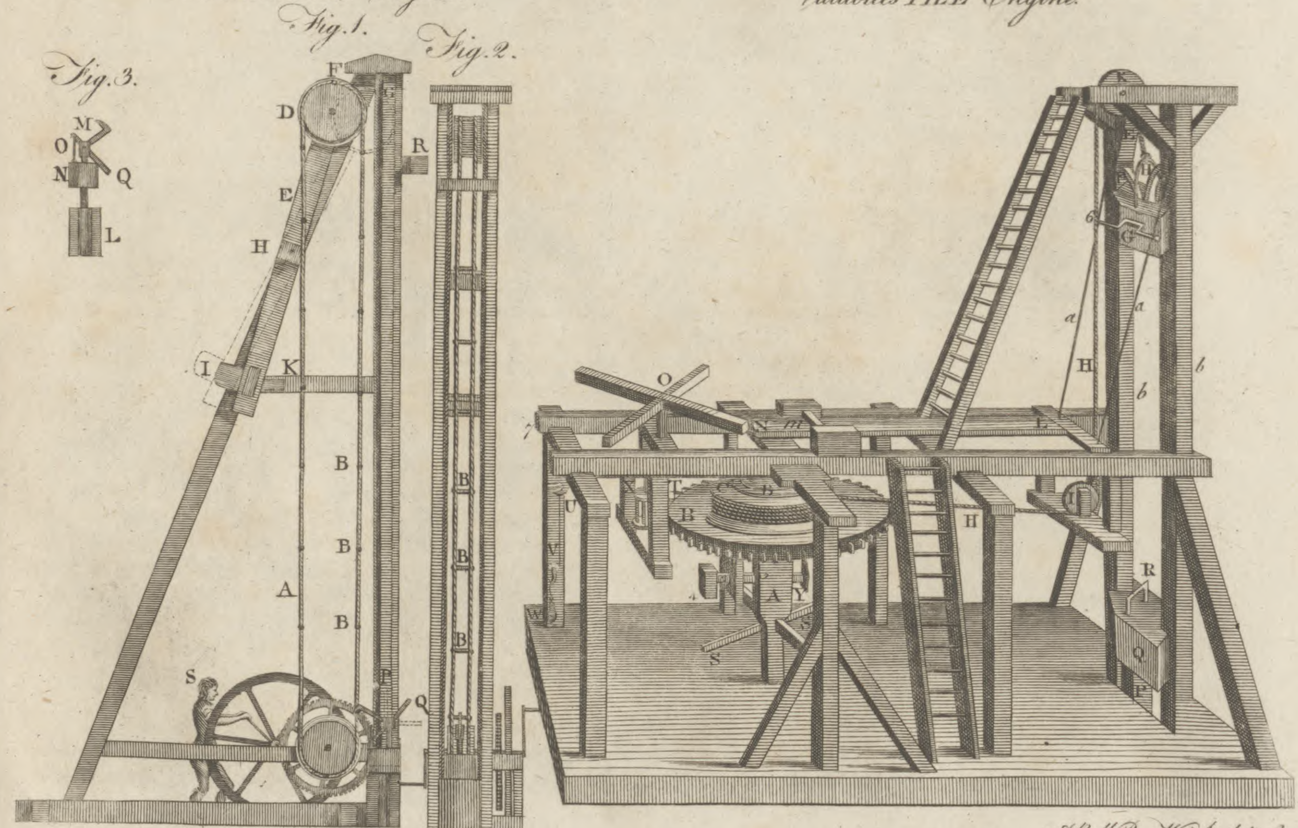
By the horſes going round, the great rope H is wound about the drum C, and the ram Q is drawn up by the tongs F in the follower G, until the tongs come between the inclined planes E; which, by ſhutting the tongs at the top, opens it at the foot, and diſcharges the ram which falls down between the guides *b b* upon the pile P, and drives it by a few ſtrokes as far into the mud as it will go; after which, the top part is ſawed off cloſe to the mud by an engine for that purpoſe. Immediately after the ram is diſcharged, the piece 6 upon the follower G takes hold of the ropes *a a*, which raiſe the end of the lever L, and cauſe its end N to deſcend and preſs down the forcing bar 5 upon the little lever

Machine for boring wooden PIPES. Plate CCCCXIX.



PILE Engine.

Bunce's PILE Engine. Vauloues PILE Engine.



A Bell Prin Wal Sculptor fecit

lever 2, which, by pulling down the bolt Y, unlocks the drum C from the great wheel B; and then the follower being at liberty, comes down by its own weight to the ram; and the lower ends of the tongs ſlip over the ſtaple R, and the weight of their heads cauſes them to fall outward, and ſhut upon it. Then the weight 4 puſhes up the bolt Y into the drum, which locks it to the great wheel, and ſo the ram is drawn up as before.

As the follower comes down, it cauſes the drum to turn backward, and unwinds the rope from it, whilſt the horſes, great wheel, trundle, and fly, go on with an uninterrupted motion; and as the drum is turning backward, the counterpoiſe W is drawn up, and its rope T wound upon the ſpiral fuſy D.

There are ſeveral holes in the under ſide of the drum, and the bolt Y always takes the firſt one that it finds when the drum ſtops by the falling of the follower upon the ram; until which ſtoppage the bolt has not time to ſlip into any of the holes.

This engine was placed upon a barge on the water, and ſo was eaſily conveyed to any place deſired. The ram was a ton weight; and the guides *b b*, by which it was let fall, were 30 feet high.

A new machine for driving piles has been invented by Mr Bunce of Kirby ſtreet, Hatton ſtreet, London. It will drive a greater number of piles in a given time than any other; and can be conſtructed more ſimply to work by horſes than Mr Vauloue's engine above deſcribed.

Plate CCCCXIX.

Fig. 1 and 2 repreſent a ſide and front ſection of the machine. The chief parts are A, fig. 1, which are two endleſs ropes, or chains, connected by croſs pieces of iron B (ſee fig. 2), correſponding with two croſs grooves cut diametrically oppoſite in the wheel C (fig. 1.), into which they are received; and by which means the rope or chain A is carried round. FHK is a ſide-view of a ſtrong wooden frame moveable on the axis H. D is a wheel, over which the chain paſſes and turns within at the top of the frame. It moves occaſionally from F to G upon the centre H, and is kept in the poſition F by the weight I fixed to the end K. Fig. 3. L is the iron ram, which is connected with the croſs pieces by the hook M. N is a cylindrical piece of wood ſuſpended at the hook at O, which by ſliding freely upon the bar that connects the hook to the ram, always brings the hook upright upon the chain when at the bottom of the machine, in the poſition of GP. See fig. 1.

When the man at S turns the uſual crane work, the ram being connected to the chain, and paſſing between the guides, is drawn up in a perpendicular direction; and when it is near the top of the machine, the projecting bar Q of the hook ſtrikes againſt a croſs piece of wood at R (fig. 1.); and conſequently diſcharges the ram, whilſt the weight I of the moveable frame inſtantly draws the upper wheel into the poſition ſhown at F, and keeps the chain free of the ram in its deſcent. The hook, while deſcending, is prevented from catching the chain by the wooden piece N. For that piece being ſpecifically lighter than the iron weight below, and moving with a leſs degree of velocity, cannot come in contact with the iron till it is at the bottom and the ram ſtops. It then falls and again connects the hook with the chain, which draws up the ram, as before.

Mr Bunce has made a model of this machine, which performs perfectly well; and he obſerves, that, as the motion of the wheel C is uninterrupted, there appears to be the leaſt poſſible time loſt in the operation.

PILE-Worms, are a kind of worms found in the piles of the ſea-dikes in Holland. They are of very various ſizes; for ſome of the young ones are not above an inch or two in length, while others have been found thirteen or fourteen inches long. The heads of theſe creatures are covered with two hard ſhells or hemicrania; which together form a figure reſembling an augre; and with which they bore the wood. The beſt remedy againſt them is, to perforate the pile with many ſmall holes about an inch aſunder; then it muſt be done over with a varniſh in the hotteſt ſun; and, while the varniſh is hot, brick duſt muſt be ſtrewed over it: and this being ſeveral times repeated, the pile will be covered with a ſtrong cruſt abſolutely impenetrable to all inſects.

PILES, in *Medicine*, the ſame with hæmorrhoids. See MEDICINE, N° 240, &c.

PILEUS, in Roman antiquity, was the ordinary cap or hat worn at public ſhows and ſacrifices, and by the freedmen. It was one of the common rewards aſſigned to ſuch gladiators as were ſlaves, in token of their obtaining freedom.

PILEWORT (*Ranunculus ficaria*, Lin.), the root. This is a very ſmall plant, found in moiſt meadows and by hedge ſides. The roots conſiſt of ſlender fibres with ſome little tubercles among them, which are ſuppoſed to reſemble the hæmorrhoids. From thence it has been concluded, that this root muſt needs be of wonderful efficacy for the cure of that diſtemper: to the taſte, it is little other than mucilaginous; and although ſtill retained in ſeveral of the foreign pharmacopœias, it is hardly in uſe in this country.

PILGRIM, one who travels through foreign countries to viſit holy places, and to pay his devotion to the relicks of dead ſaints. See PILGRIMAGE.

The word is formed from the Flemiſh *pelgrim*, or Italian *pelegrino*, which ſignifies the ſame; and thoſe originally from the Latin *peregrinus*, a "ſtranger or traveller."

PILGRIMAGE, a kind of religious diſcipline, which conſiſts in taking a journey to ſome holy place in order to adore the relicks of ſome deceaſed ſaint. Pilgrimages began to be made about the middle ages of the church; but they were moſt in vogue after the end of the 11th century, when every one was for viſiting places of devotion, not excepting kings and princes themſelves; and even biſhops made no difficulty of being abſent from their churches on the ſame account. The places moſt viſited were Jeruſalem, Rome, Compoſtella (A), and Tours; but the greateſt numbers now reſort

(A) It deſerves to be remarked here, that in the year 1428, under the reign of Henry VI. abundance of licences were granted from the crown of England to captains of Engliſh ſhips, for carrying numbers of devout perſons to the ſhrine of St James of Compoſtella in Spain; provided, however, that thoſe pilgrims ſhould firſt take an oath not

Pilgrimage. resort to Loretto, in order to visit the chamber of the blessed virgin, in which she was born, and brought up her son Jesus till he was 12 years of age. For the pilgrimage of the followers of Mahomet, see MAHOMETANISM.

In every country where popery was established, pilgrimages were common; and in those countries which are still popish, they continue. In England, the shrine of St Thomas à Becket was the chief resort of the pious; and in Scotland, St Andrews; where, as tradition informs us, was deposited a leg of the holy apostle. In Ireland they still continue; for, from the beginning of May till the middle of August every year, crowds of popish penitents from all parts of that country resort to an island near the centre of *Lough-fin*, or *White Lake*, in the county of Donnegal, to the amount of 3000 or 4000. These are mostly of the poorer sort, and many of them are proxies for those who are richer; some of which, however, together with some of the priests and bishops on occasion, make their appearance there. When the pilgrim comes within sight of the holy lake, he must uncover his hands and feet, and thus walk to the water-side, and is taken to the island for sixpence. Here there are two chapels and 15 other houses; to which are added confessionals, so contrived, that the priest cannot see the person confessing. The penance varies according to the circumstances of the penitent; during the continuance of which (which is sometimes three, six, or nine days) he subsists on oatmeal, sometimes made into bread. He traverses sharp stones on his bare knees or feet, and goes through a variety of other forms, paying sixpence at every different confession. When all is over, the priest bores a gimblet-hole through the pilgrim's staff near the top, in which he fastens a cross peg; gives him as many holy pebbles out of the lake as he cares to carry away, for amulets to be presented to his friends, and so dismisses him, an object of veneration to all other papists not thus initiated, who no sooner see the pilgrim's cross in his hands, than they kneel down to get his blessing.

There are, however, other parts of Ireland sacred to extraordinary worship and pilgrimage; and the number of holy wells, and miraculous cures, &c. produced by them, is very great. That such things should exist in this enlightened age, and in a Protestant country, is indeed strange; but our wonder ceases, when we reflect that it is among the lowest, and perhaps the worst of the people. They who carry external religion to an extreme, and place that confidence in ceremony which belongs only to the spirit of it, are seldom distinguished either for their wisdom or their virtue. We do not deny, however, that they who carry matters to the other extreme, may be equally destitute of real knowledge and genuine morality.

Dr Johnson, in his *Rasselas*, gives us some observations on pilgrimage, which are so much to the purpose, that we think we cannot do better than lay them before our readers. "Pilgrimage (said Imlac, into whose mouth the observations are put), like many other acts of piety, may be reasonable or superstitious according to the principles upon which it is performed. Long journeys in search of truth are not commanded. Truth, such as is necessary to the regulation of life, is always found where it is honestly sought: change of place is no natural cause of the increase of piety, for it inevitably produces dissipation of mind. Yet since men go every day to view the fields where great actions have been performed, and return with stronger impressions of the event, curiosity of the same kind may naturally dispose us to view that country whence our religion had its beginning: and I believe no man surveys those awful scenes without some confirmation of holy resolutions. That the Supreme Being may be more easily propitiated in one place than in another, is the dream of idle superstition; but that some places may operate upon our own minds in an uncommon manner, is an opinion which hourly experience will justify. He who supposes that his vices may be more successfully combated in Palestine, will, perhaps, find himself mistaken; yet he may go thither without folly: he who thinks they will be more freely pardoned, dishonours at once his reason and religion."

Pilgrimage || Pill.

PILKINGTON, LÆTITIA, a famous poetical genius, the daughter of Dr Van Lewin, a physician of Dublin, where she was born in 1712. She was married very young to the Rev. Matthew Pilkington, a poet also of no inconsiderable merit; and the two wits, as is often the case, lived very unhappily together. They were at length totally separated, on the husband accidentally discovering a gentleman in her bedchamber at two o'clock in the morning; a circumstance which she accounted for in a very unsatisfactory manner. The story is told at large in her Memoirs; where she says, "Lovers of learning, I am sure, will pardon me, as I solemnly declare it was the attractive charms of a new book, which the gentleman would not lend me, but consented to stay till I read it through, that was the sole motive of my detaining him." As there are not wanting some who form objections to marrying learned wives, the chance of such literary assignations may perhaps be added to the list of them. After this unlucky adventure, Mrs Pilkington came to London; and having recourse to her pen for subsistence, through the means of Colley Cibber, she lived for some time on the contributions of the great. She was however thrown into the Marshalsea for debt; and being set at liberty, opened a pamphlet shop. She raised at length a handsome subscription for her Memoirs; which are written with great sprightliness and wit, containing several entertaining anecdotes of Dean Swift, with whom she was intimate, as well as many pretty little pieces of her own poetry. This ingenious woman is said at last to have killed herself with drinking. She died at Dublin, in 1750.

PILL, in *pharmacy*, a form of medicine resembling a little ball, to be swallowed whole; invented for such as

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not to take any thing prejudicial to England, not to reveal any of its secrets, nor to carry out with them any more gold or silver than what would be sufficient for their reasonable expences. In this year there went out thither from England, on the said pilgrimage, the following number of persons. From London 280, Bristol 200, Weymouth 122, Dartmouth 90, Yarmouth 60, Jersey 60, Plymouth 40, Exeter 30, Poole 24, Ipswich 20, in all 926 persons.

as cannot take bitter and ill-tafted medicinal draughts: as alfo to keep in readinefs for occafional ufe without decaying. See MATERIA MEDICA *Index*.

PILLAR, in architecture. See ARCHITECTURE.

PILLAR, in the manege, is the centre of the ring, or manege-ground, round which a horfe turns, whether there be a pillar in it or not. Befides this, there are pillars on the circumference or fides of the manege-ground, placed at certain diftances, by two and two, from whence they are called the *two pillars*, to diftinguifh them from that of the centre. The ufe of the pillar in the centre is for regulating the extent of ground, that the manege upon the volts may be performed with method and juftnefs, and that they may work in a fquare, by rule and meafure, upon the four lines of the volts; and alfo to break unruly high-mettled horfes, without endangering the rider. The two pillars are placed at the diftance of two or three paces one from the other; and the horfe is put between thofe, to teach him to rife before and yerk out behind, and put himfelf upon raifed airs, &c. either by the aids or chaftifements.

Pompey's PILLAR. See ALEXANDRIA.

PILLARS, in antiquarian topography, are large fingle ftones fet up perpendicularly. Thofe of them which are found in this country have been the work of the Druids; but as they are the moft fimple of all monuments, they are unqueftionably more ancient than druidifm itfelf. They were placed as memorials recording different events; fuch as remarkable inftances of God's mercies, contracts, fingular victories, boundaries, and fometimes fepulchres. Various inftances of thefe monuments erected by the patriarchs occur in the Old Teftament: fuch was that raifed by Jacob at Luz, afterwards by him named *Bethel;* fuch alfo was the pillar placed by him over the grave of Rachel. They were likewife marks of execrations and magical talifmans.

Thefe ftones, from having long been confidered as objects of veneration, at length were by the ignorant and fuperftitious idolatroufly worfhipped; wherefore, after the introduction of Chriftianity, fome had croffes cut on them, which was confidered as fnatching them from the fervice of the devil. Vulgar fuperftition of a later date has led the common people to confider them as perfons transformed into ftone for the punifhment of fome crime, generally that of fabbath-breaking; but this tale is not confined to fingle ftones, but is told alfo of whole circles: witnefs the monuments called the *hurlers* in Cornwall, and *Rollorick ftones* in Warwickfhire. The firft are by the vulgar fuppofed to have been once men, and thus transformed as a punifhment for playing on the Lord's day at a game called *hurling;* the latter, a pagan king and his army.

At Wilton, where the earl of Pembroke has a very magnificent houfe, there is a pillar of one piece of white Egyptian granite, which was brought from the temple of Venus Genetrix at Rome, near 14 feet high and 22 inches diameter, with an infcription to Aftarte or Venus.

PILLORY (*colliftrigium*, "collum ftringens;" *pilloria*, from the French *pilleur*, i. e. *depeculator;* or *pelori*, derived from the Greek πυλη, *janua*, a "door," becaufe one ftanding on the pillory puts his head as it were through a door, and ορωω, *video*), is an engine made of wood to punifh offenders, by expofing them to public view, and rendering them infamous. There is a *ftatute of the pillory*, 51 Hen. III. And by ftatute it is appointed for bakers, foreftallers, and thofe who ufe falfe weights, perjury, forgery, &c. 3 *Inft.* 219. Lords of leets are to have a pillory and tumbrel, or it will be the caufe of forfeiture of the leet; and a village may be bound by prefcription to provide a pillory, &c. 2 *Hawk. P. C.* 73.

PILOT, the officer who fuperintends the navigation, either upon the fea-coaft or on the main ocean. It is, however, more particularly applied by our mariners to the perfon charged with the direction of a fhip's courfe on or near the fea-coaft, and into the roads, bays, rivers, havens, &c. within his refpective diftrict.

Pilots of fhips, taking upon them to conduct any fhip from Dover, &c. to any place up the river Thames, are to be firft examined and approved by the mafter and wardens of the fociety of Trinity Houfe, &c. or fhall forfeit 10l. for the firft offence, 20l. for the fecond, and 40l. for every other offence; one moiety to the informer, the other to the mafter and wardens; but any mafter or mate of a fhip may pilot his own veffel up the river: and if any fhip be loft through the negligence of any pilot, he fhall be for ever after difabled to act as a pilot. 3 Geo. I. c. 13. Alfo the lord-warden of the cinque ports may make rules for the government of pilots, and order a fufficient number to ply at fea to conduct fhips up to the Thames: 7 Geo. I. c. 21. No perfon fhall act as a pilot on the Thames, &c. (except in collier fhips) without a licence from the mafter and wardens of Trinity Houfe at Deptford, on pain of forfeiting 20l. And pilots are to be fubject to the government of that corporation; and pay ancient dues, not exceeding 1s. in the pound, out of wages, for the ufe of the poor thereof. Stat. 5 Geo. II. c. 20.

By the former laws of France, no perfon could be received as pilot till he had made feveral voyages and paffed a ftrict examination; and after that, on his return in long voyages, he was obliged to lodge a copy of his journal in the admiralty; and if a pilot occafioned the lofs of a fhip, he had to pay 100 livres fine, and to be for ever deprived of the exercife of pilotage; and if he did it defignedly, be punifhed with death. *Lex Mercat.* 70, 71.

The laws of Oleron ordain, That if any pilot defignedly mifguide a fhip, that it may be caft away, he fhall be put to a rigorous death, and hung in chains: and if the lord of a place, where a fhip be thus loft, abet fuch villains in order to have a fhare of the wreck, he fhall be apprehended, and all his goods forfeited for the fatisfaction of the perfons fuffering; and his perfon fhall be faftened to a ftake in the midft of his own manfion, which, being fired on the four corners, fhall be burned to the ground, and he with it. *Leg. Ol.* c. 25. And if the fault of a pilot be fo notorious, that the fhip's crew fee an apparent wreck, they may lead him to the hatches, and ftrike off his head; but the common law denies this hafty execution: an ignorant pilot is fentenced to pafs thrice under the fhip's keel by the laws of Denmark. *Lex Mercat.* 70.

The regulations with regard to pilots in the royal navy are as follow: "The commanders of the king's fhips, in order to give all reafonable encouragement to fo ufeful a body of men as pilots, and to remove all their objections to his majesty's service, are strictly charged to treat them with good usage, and an equal respect with warrant-officers.

"The purser of the ship is always to have a set of bedding provided on board for the pilots; and the captain is to order the boatswain to supply them with hammocks, and a convenient place to lie in, near their duty, and apart from the common men; which bedding and hammocks are to be returned when the pilots leave the ship.

"A pilot, when conducting one of his majesty's ships in pilot-water, shall have the sole charge and command of the ship, and may give orders for steering, setting, trimming, or furling the sails; tacking the ship; or whatever concerns the navigation: and the captain is to take care that all the officers and crew obey his orders. But the captain is diligently to observe the conduct of the pilot; and if he judges him to behave so ill as to bring the ship into danger, he may remove him from the command and charge of the ship, and take such methods for her preservation as shall be judged necessary; remarking upon the log book, the exact hour and time when the pilot was removed from his office, and the reasons assigned for it.

"Captains of the king's ships, employing pilots in foreign parts of his majesty's dominions, shall, after performance of the service, give a certificate thereof to the pilot, which being produced to the proper naval officer, he shall cause the same to be immediately paid; but if there be no naval-officer there, the captain of his majesty's ship shall pay him, and send the proper vouchers, with his bill, to the navy-board, in order to be paid as bills of exchange.

"Captains of his majesty's ships, employing foreign pilots to carry the ships they command into or out of foreign ports, shall pay them the rates due by the establishment or custom of the country, before they discharge them: whose receipts being duly vouched, and sent, with a certificate of the service performed, to the navy-board, they shall cause them to be paid with the same exactness as they do bills of exchange." *Regulations and Instructions of the Sea-service*, &c.

PILOT-Fish. See GASTEROSTEUS, ICHTHYOLOGY *Index.*

Osbec tells us, that they are shaped like those mackerels which have a transverse line upon the body. "Sailors (continues he) give them the name of *pilots*, because they closely follow the dog-fish, swimming in great shoals round it on all sides. It is thought that they point out some prey to the dog-fish. They are not only not touched, but also preserved by it against all their enemies.

It likewise follows the shark, apparently for the purpose of devouring the remains of its prey. It is pretended that it acts as its pilot. The manner in which it attends the shark, according to M. Daubenton, may have given rise to this name. It is said to swim at the height of a foot and a half from the snout of this voracious animal, to follow and imitate all its movements, and to seize with address every part of its prey which the shark allows to escape, and which is light enough to buoy up towards the surface of the water. When the shark, which has its mouth below, turns to seize any fish, the pilot-fish starts away; but as soon as the shark resumes his ordinary position, it returns to its former place. It is said, that in the gulf of Guinea those fishes follow ships for the sake of the offals and human excrements; and hence the Dutch give them the name of *dung-fish.* It is remarkable, that though so small they can keep pace with ships in their swiftest course.

PILTEN, a division of Courland, which lies in Courland properly so called, derives its name from the ancient castle or palace of Pilten, built by Valdemar II. king of Denmark about the year 1220, when he founded a bishop's see in this country for the more effectual conversion of its Pagan inhabitants. This district afterwards successively belonged to the Germans, then again to the king of Denmark, the duke of Courland, and to Poland; and by virtue of the instrument of regency drawn up for this district in the year 1717, the government is lodged in seven Polish senators or counsellors, from whom an appeal lies to the king. The bishop of Samogitia also styles himself bishop of Pilten.

The most remarkable part of this district is the promontory of Domesness, which projects northward into the gulf of Livonia. From this cape, a sand-bank runs four German miles farther into the sea, half of which lies under water, and cannot be discerned. To the east of this promontory is an unfathomable abyss, which is never observed to be agitated. For the safety of vessels bound to Livonia, two square beacons have been erected on the coast, near Domesness church, opposite to the sand bank, and facing each other. One of these is twelve fathoms high, and the other eight; and a large fire is kept burning on them from the first of August to the first of January. When the mariners see these fires appear as one in a direct line, they may conclude that they are clear of the extremity of the sand bank, and consequently out of danger; but if they see both beacons, they are in danger of running upon it. The district of Pilten contains seven parishes, but no towns worthy of notice. The inhabitants are chiefly of the Lutheran persuasion.

PILUM, a missive weapon used by the Roman soldiers, and in a charge darted upon the enemy. Its point, we are told by Polybius, was so long and small, that after the first discharge it was generally so bent as to be rendered useless. The legionary soldiers made use of the pilum, and each man carried two. The pilum underwent many alterations and improvements, insomuch that it is impossible with any precision to describe it. Julius Scaliger laboured much to give an accurate account of it, and would have esteemed success on this head amongst the greatest blessings of his life. This weapon appears, however, to have been sometimes round, but most commonly square, to have been two cubits long in the staff, and to have had an iron point of the same length hooked and jagged at the end. Marius made a material improvement in it; for during the Cimbrian war, he so contrived it, that when it stuck in the enemies shield it should bend down in an angle in the part where the wood was connected with the iron, and thus become useless to the person who received it.

PIMENTO, PIEMENTO, JAMAICA PEPPER, or *All-spice*, a species of myrtus. See MYRTUS, BOTANY *Index.*

"The pimento trees grow spontaneously, and in great abundance, in many parts of Jamaica, but more particularly on hilly situations near the sea, on the northern side of that island; where they form the most

most delicious groves that can possibly be imagined; filling the air with fragrance, and giving reality, though in a very distant part of the globe, to our great poet's description of those balmy gales which convey to the delighted voyager

> 'Sabean odours from the spicy shore
> 'Of Araby the blest.
> 'Chear'd with the grateful smell, old ocean smiles.'

"This tree is purely a child of nature, and seems to mock all the labours of man in his endeavours to extend or improve its growth: not one attempt in fifty to propagate the young plants, or to raise them from the seeds, in parts of the country where it is not found growing spontaneously, having succeeded. The usual method of forming a new pimento plantation (in Jamaica it is called a *walk*) is nothing more than to appropriate a piece of woodland, in the neighbourhood of a plantation already existing, or in a country where the scattered trees are found in a native state, the woods of which being fallen, the trees are suffered to remain on the ground till they become rotten and perish. In the course of twelve months after the first season, abundance of young pimento plants will be found growing vigorously in all parts of the land, being without doubt produced from ripe berries scattered there by the birds, while the fallen trees, &c. afford them both shelter and shade. At the end of two years it will be proper to give the land a thorough cleansing, leaving such only of the pimento trees as have a good appearance, which will then soon form such groves as those I have described, and, except perhaps for the first four or five years, require very little attention afterwards.

"Soon after the trees are in blossom, the berries become fit for gathering; the fruit not being suffered to ripen on the tree, as the pulp in that state, being moist and glutinous, is difficult to cure, and when dry becomes black and tasteless. It is impossible, however, to prevent some of the ripe berries from mixing with the rest; but if the proportion of them be great, the price of the commodity is considerably injured.

"It is gathered by the hand; one labourer on the tree, employed in gathering the small branches, will give employment to three below (who are generally women and children) in picking the berries; and an industrious picker will fill a bag of 70lbs in the day.

"The returns from a pimento walk in a favourable season are prodigious. A single tree has been known to yield 150 lbs. of the raw fruit, or one cwt. of the dried spice; there being commonly a loss in weight of one third in curing; but this, like many other of the minor productions, is exceedingly uncertain, and perhaps a very plenteous crop occurs but once in five years."

PIMPINELLA, Burnet Saxifrage; a genus of plants belonging to the pentandria class. See Botany *Index*.

PIMPLE, in *Medicine*, a small pustule arising on the face. By mixing equal quantities of the juice of house-leek (*sedum minus*), passed through paper, and of spirit of wine rectified by itself, a white coagulum of a very volatile nature is formed, which Dr Bughart commends for curing pimples of the face; and says, that the thin liquor separated from it with sugarcandy is an excellent remedy for thick viscid phlegm in the breast.

PIN, in commerce, a little necessary instrument made of brass-wire, chiefly used by women in fastening and adjusting their dress.

In the year 1543, by statute 34 and 35 of Henry VIII. cap. 6. it was enacted, "That no person shall put to sale any pinnes but only such as shall be double-headed, and have the heads soldered fast to the shank of the pins, well smoothed, the shank well-shapen, the points well and round filed, cauted, and sharpened." From the above extract it should appear that the art of pin-making was but of late invention, probably introduced from France; and that our manufactories since that period have wonderfully improved.

Though pins are apparently simple, their manufacture is, however, not a little curious and complex. We shall therefore give our readers an account of it from Ellis's *Campagna* of London.

"When the brass-wire, of which the pins are formed, is first received at the manufactory, it is generally too thick for the purpose of being cut into pins. The first operation therefore is that of winding it off from one wheel to another with great velocity, and causing it to pass between the two, through a circle in a piece of iron of smaller diameter: the wire being thus reduced to its proper dimensions, is straitened by drawing it between iron pins, fixed in a board in a zig-zag manner, but so as to leave a straight line between them: afterwards it is cut into lengths of three or four yards, and then into smaller ones, every length being sufficient to make six pins; each end of these is ground to a point, which was performed when I viewed the manufactory by boys who sat each with two small grinding stones before him, turned by a wheel. Taking up a handful, he applies the ends to the coarsest of the two stones, being careful at the same time to keep each piece moving round between his fingers, so that the points may not become flat: he then gives them a smoother and sharper point, by applying them to the other stone, and by that means a lad of 12 or 14 years of age is enabled to point about 16,000 pins in an hour. When the wire is thus pointed, a pin is taken off from each end, and this is repeated till it is cut into six pieces. The next operation is that of forming the heads, or, as they term it, *head-spinning;* which is done by means of a spinning-wheel, one piece of wire being thus with astonishing rapidity wound round another, and the interior one being drawn out, leaves a hollow tube between the circumvolutions: it is then cut with sheers; every two circumvolutions or turns of the wire forming one head; these are softened by throwing them into iron pans, and placing them in a furnace till they are red hot. As soon as they are cold, they are distributed to children, who sit with anvils and hammers before them, which they work with their feet, by means of a lathe, and taking up one of the lengths, they thrust the blunt end into a quantity of the heads which lie before them, and catching one at the extremity, they apply them immediately to the anvil and hammer, and by a motion or two of the foot, the point and the head are fixed together in much less time than it can be described, and with a dexterity only to be acquired by practice; the spectator being in continual apprehension

sion for the safety of their fingers ends. The pin is now finished as to its form, but still it is merely brass; it is therefore thrown into a copper, containing a solution of tin and the leys of wine. Here it remains for some time; and when taken out assumes a white though dull appearance: in order therefore to give it a polish, it is put into a tub containing a quantity of bran, which is set in motion by turning a shaft that runs through its centre, and thus by means of friction it becomes perfectly bright. The pin being complete, nothing remains but to separate it from the bran, which is performed by a mode exactly similar to the winnowing of corn; the bran flying off and leaving the pin behind fit for immediate sale. I was the more pleased with this manufactory, as it appeared to afford employment to a number of children of both sexes, who are thus not only prevented from acquiring the habits of idleness and vice, but are on the contrary initiated in their early years in those of a beneficial and virtuous industry." See NEEDLES.

PINACIA, among the Athenians, were tablets of brass inscribed with the names of all those citizens in each tribe who were duly qualified and willing to be judges of the court of Areopagus. These tablets were cast into a vessel provided for the purpose, and the same number of beans, a hundred being white and all the rest black, were thrown into another. Then the names of the candidates and the beans were drawn out one by one, and they whose names were drawn out together with the white beans were elected judges or senators. In Solon's time there were only four tribes, each of which chose 100 senators; but the number of tribes afterwards increasing, the number of senators and judges increased to so many hundreds more.

PINANG, the Chinese name of the *Areca Catechu* Lin. See ARECA, BOTANY *Index*.

PINCHBECK, a factitious metallic substance, or an alloy of zinc three parts, and of copper, four. See CHEMISTRY *Index*.

PINDAR, the prince of lyric poets, was born at Thebes, about 520 years B. C. He received his first musical instructions from his father, who was a flute-player by profession; after which, according to Suidas, he was placed under Myrtis, a lady of distinguished abilities in lyric poetry. It was during this period that he became acquainted with the poetess Corinna, who was likewise a student under Myrtis. Plutarch tell us, that Pindar profited from the lessons which Corinna, more advanced in her studies, gave him at this school. It is very natural to suppose, that the first poetical effusions of a genius so full of fire and imagination as that of Pindar would be wild and luxuriant; and Lucian has preserved six verses, said to have been the exordium of his first essay; in which he crowded almost all the subjects for song which ancient history and mythology then furnished. Upon communicating this attempt to Corinna, she told him smiling, that he should sow with the hand, and not empty his whole sack at once. Pindar, however, soon quitted the leading strings of these ladies, his poetical nurses, and became the disciple of Simonides, now arrived at extreme old age: after which he soon surpassed all his masters, and acquired great reputation over all Greece: but, like a true prophet, he was less honoured in his own country than elsewhere; for at Thebes he was frequently pronounced to be vanquished, in the musical and poetical contests, by candidates of inferior merit.

The custom of having these public trials of skill in all the great cities of Greece was now so prevalent, that but little fame was to be acquired by a musician or poet any other way than by entering the lists; and we find, that both Myrtis and Corinna publicly disputed the prize with him at Thebes. He obtained a victory over Myrtis, but was vanquished five different times by Corinna. The judges, upon occasions like these, have been frequently accused of partiality or ignorance, not only by the vanquished, but by posterity; and if the merit of Pindar was pronounced inferior to that of Corinna five several times, it was, says Pausanias, because the judges were more sensible to the charms of beauty than to those of music and poetry (A). Was is not strange, said the Scythian Anacharsis, that the Grecian artists were never judged by artists, their peers?

Pindar, before he quitted Thebes, had the vexation to see his Dithyrambics traduced, abused, and turned into ridicule, by the comic poets of his time; and Athenæus tells us, that he was severely censured by his brother lyrics, for being a lipogrammatist, and composing an ode from which he had excommunicated the letter S. Whether these censures proceeded from envy or contempt cannot now be determined; but they were certainly useful to Pindar, and it was necessary that he should be lashed for such puerilities. Thebes seems to have been the purgatory of our young bard: when he quitted that city, as his judgement was matured, he avoided most of the errors for which he had been chastised, and suddenly became the wonder and delight of all Greece. Every hero, prince, and potentate, desirous of lasting fame, courted the muse of Pindar.

He seems frequently to have been present at the four great festivals, of the Olympian, Pythian, Nemean, and Isthmian games, as may be inferred from several circumstances and expressions in the odes which he composed for the victors in them all. Those at Olympia, who were ambitious of having their atchievements celebrated by Pindar, applied to him for an ode, which was first sung in the Prytaneum or town-hall of Olympia, where there was a banqueting room, set apart for the entertainment of the conquerors. Here the ode was rehearsed by a chorus, accompanied by instruments. It was afterwards performed in the same manner at the triumphal entry of the victor into his own country, in processions, or at the sacrifices that were made with great pomp and solemnity on the occasion.

Pindar,

(A) Pausanias says, that Corinna was one of the most beautiful women of her time, as he judged by a picture of her which he saw at Tanagris at the place where the public exercises were performed. She was represented with her head ornamented by a riband, as a memorial of the victories she had obtained over Pindar at Thebes.

Pindar, in his fecond Ifthmian ode, has apologized for the mercenary cuftom among poets, of receiving money for their compofitions. "The world (fays he) is grown interefted, and thinks in general with the Spartan philofopher Ariftodemus, that *money only makes the man*: a truth which this fage himfelf experienced, having with his riches loft all his friends." It is fuppofed that Pindar here alludes to the avarice of Simonides, who firft allowed his mufe to fell her favours to the higheft bidder.

There is no great poet in antiquity whofe moral character has been lefs cenfured than that of Pindar. Plutarch has preferved a fingle verfe of his *Epicedium* or *Dirge* that was fung at his funeral; which, fhort and fimple as it is, implies great praife: *This man was pleafing to ftrangers, and dear to his fellow-citizens.* His works abound with precepts of the pureft morality: and it does not appear that he ever traduced even his enemies; comforting himfelf, for their malignity, by a maxim which he inferted in his firft *Pythic*, and which afterwards became proverbial, *That it is better to be envied than pitied.*

Paufanias fays, that the character of poet was truly confecrated, in the perfon of Pindar, by the god of verfe himfelf; who was pleafed, by an exprefs oracle, to order the inhabitants of Delphos to fet apart for Pindar one half of the firft-fruit offerings brought by the religious to his fhrine, and to allow him a confpicuous place in his temple, where, in an iron chair, he ufed to fit and fing his hymns in honour of that god. This chair was remaining in the time of Paufanias, feveral centuries after, and fhown to him as a relick not unworthy of the fanctity and magnificence of that place.

But though Pindar's mufe was penfioned at Delphos, and well paid by princes and potentates elfewhere, fhe feems, however, fometimes to have fung the fpontaneous ftrains of pure friendfhip. Of this kind were, probably, the verfes beftowed upon the mufician Midas, of Agrigentum in Sicily, who had twice obtained the palm of victory by his performance on the flute at the Pythic games (B). It is in his 12th Pythic ode that Pindar celebrates the victory of Midas *over all Greece, upon that inftrument which Minerva herfelf had invented* (C)

Fabricius tells us, that Pindar lived to the age of 90; and, according to the chronology of Dr Blair, he died 435 years B. C. aged 86. His fellow citizens erected a monument to him in the Hippodrome at Thebes, which was ftill fubfifting in the time of Paufanias; and his renown was fo great after his death, that his pofterity derived very confiderable honours and privileges from it. When Alexander the Great attacked the city of Thebes, he gave exprefs orders to his foldiers to fpare the houfe and family of Pindar. The Lacedemonians had done the fame before this period; for when they ravaged Bœotia and burned the capital, the following words were written upon the door of the poet: *Forbear to burn this houfe, it was the dwelling of Pindar.* Refpect for the memory of this great poet continued fo long, that, even in Plutarch's time, the beft part of the facred victim at the Theoxenian feftival was appropriated to his defcendants.

PINDARIC ODE, in *Poetry*, an ode formed in imitation of the manner of Pindar. See POETRY, n° 136, &c.

PINDUS, in *Ancient Geography*, not a fingle mountain, but a chain of mountains, inhabited by different people of Epirus and Theffaly; feparating Macedonia, Theffaly, and Epirus: An extenfive chain, having Macedonia to the north, the Perrhœbi to the weft, the Dolopes to the fouth, and the mountain itfelf of Theffaly (Strabo).

PINDUS, a Doric city of Ætolia, fituated on the cognominal river, which falls into the Cephiffus (Strabo.)

PINE, in *Botany*. See PINUS, BOTANY *Index*.

PINE-Apple. See BROMELIA, BOTANY *Index*; and for an account of the mode of cultivating the pine-apple, fee GARDENING.

PINEA, or PIGNE, in commerce, is a term ufed in Peru and Chili, for a kind of light, porous maffes, or lumps, formed of a mixture of mercury and filver-duft from the mines. The ore, or mineral, of filver, when dug out of the veins of the mine, is firft broken and then ground in mills for the purpofe, driven by water with iron peftles, each of 200 pounds weight. The mineral, when thus pulverized, is next fifted, and then worked up with water into a pafte; which, when half dry, is cut into pieces, called *cuerpos*, a foot long, weighing each about two thoufand five hundred pounds.

Each piece or cuerpo is again kneaded up with fea-falt, which, diffolving, incorporates with it. They then add mercury, from 10 to 20 pounds for each cuerpo, kneading the pafte afrefh until the mercury be incorporated therewith. This office, which is exceedingly dangerous on account of the noxious qualities of the mercury, is always made the lot of the poor Indians. This amalgamation is continued for eight or nine days; and fome add lime, lead, or tin ore, &c. to forward it; and, in fome mines, they are obliged to ufe fire. To try whether or no the mixture and amalgamation be fufficient, they wafh a piece in water; and if the mercury be white, it is a proof that it has had its effect; if black, it muft be ftill farther worked.

(B) This Midas is a very different perfonage from his long-eared majefty of Phrygia, whofe decifion in favour of Pan had given fuch offence to Apollo; as is manifeft, indeed, from his having been cotemporary with Pindar.

(C) The moft extraordinary part of this mufician's performance that can be gathered from the fcholiaft upon Pindar, was his finifhing the folo, without a reed or mouth-piece, which broke accidentally while he was playing. The legendary account given by the poet in this ode, of the occafion upon which the flute was invented by Minerva, is diverting: "It was (fays he) to imitate the howling of the Gorgons, and the hiffing of their fnakes, which the goddefs had heard when the head of Medufa (one of thefe three anti-graces) was cut off by Perfeus."

ed. When finished, it is sent to the lavatories, which are large basons that empty successively into one another. The paste, &c. being laid in the uppermost of these, the earth is then washed from it into the rest by a rivulet turned upon it; an Indian, all the while, stirring it with his feet, and two other Indians doing the like in the other basons. When the water runs quite clear out of the basons, the mercury and silver are found at bottom incorporated. This matter they call *pella*, and of this they form the pineas, by expressing as much of the mercury as they can; first, by putting it in woollen bags, and pressing and beating it strongly; then, by stamping it in a kind of wooden mould, of an octagonal form, at bottom whereof is a brass plate pierced full of little holes. The matter, when taken out of the mould, is laid on a trivet, under which is a large vessel full of water; and the whole being covered with an earthen head, a fire is made round it.

The mercury still remains in the mass, and is thus reduced into fumes, and, at length condensing, it is precipitated into the water, leaving behind it a mass of silver grains of different figures, which, only joining or touching at the extremes, render the matter very porous and light. This, therefore, is the pinea, or pigne, which the workmen endeavour to sell secretly to vessels trading to the South sea; and from which those, who have ventured to engage in so dangerous a commerce, have made such vast gains. Indeed the traders herein must be very careful; for the Spanish miners are arrant knaves, and to make the pignes weigh the more, they often fill the middle with sand or iron.

PINEAL GLAND. See BRAIN, ANATOMY *Index*.

PINEAU, GABRIEL DU, a distinguished lawyer, was born at Angers in 1573. He went afterwards to Paris, and pled with eclat before the parliament and great council. Upon his return to Angers, he became a counsellor in the presidial court. He was consulted by all the neighbouring provinces, and had an active hand in all the great affairs of his time. Mary de Medicis conferred upon him the office of master of requests, and in her disgrace wished to support herself by his credit and counsels; but Du Pineau, always attentive to what he owed on the one hand to the mother of his king, and on the other to the king himself, never ceased to inspire that princess with sentiments of peace.

In 1632 Louis XIII. by way of reward, appointed him mayor and captain-general of the city of Angers; a situation in which he merited the flattering title of *Father of the People*. He had no respect of persons; for he was equally accessible to the poor and the great. This worthy citizen died the 15th of October 1644, at the age of 71. His house was a kind of academy, where regular conferences were held, and attended by young officers, advocates, and other literary characters. In those conferences every one freely stated the difficulties which occurred to him upon subjects either of law or history; and when Pineau spoke, all was made clear; but he was always the last in delivering his sentiments, because he perceived that too much deference was paid to his opinion. His writings are, 1. Latin notes, in addition to those of Du Moulin, upon the canon law, and printed along with the works of that eminent lawyer by the care of Francis Pinson. 2. Commentaries, observations, and consultations, upon several important questions respecting the laws both of Anjou and of France, with some dissertations upon different subjects, &c. reprinted in 1725, in 2 vol. folio, by the care of Livoniere, who has enriched them with very useful remarks. The editor says, that "Du Pineau is a little inferior to the celebrated Du Moulin on the civil law, but that he is more accurate than the other upon the canon law."—Menage made these two verses upon his death:

Pinellus periit, Themidis pius ille sacerdos,
In proprio judex limine perpetuus.

PINEDA, JOHN, a writer of history, was born at Seville of a noble family, and entered into the society of Jesuits in 1572. He taught philosophy and divinity in several colleges; and devoted his time to the study of the Holy Scriptures. That he might render that study the easier, he made himself master of the oriental languages. We have of his writings, 1. Two volumes of Commentaries upon the book of Job, in folio. 2. Two upon Ecclesiastes. 3. A General History of the Church, in Spanish, 4 vol. in folio. 4. A History of Ferdinand III. in the same language, in folio. He died in 1637, much regretted by the members of his society, and by the public in general.

PINELLI, JOHN VINCENT, a distinguished literary character, was born at Naples, and was son of Count Pinelli, a noble Genoese, who had settled in that city, and had acquired a handsome fortune in the way of trade. After receiving a liberal education, he quitted the place of his nativity, and repaired to Padua, where he took up his residence at the age of 24. Being a great lover of science, he gave a preference to that city on account of its famous university, which brought to it a number of learned men. He had an excellent library, which consisted of a choice collection of books and manuscripts, and which he continued to enrich till the hour of his death. His literary correspondence, not only in Italy, but through the most of Europe, procured him all the new works which were worthy of a place in his collection. The authors themselves were often forward to pay their respects to him. In many cities of Italy he had persons employed to search, at least once a month, the stalls of those artificers who make use of old parchments, such as lute-makers, sievewrights, and others; and by this means he had the good fortune often to save from destruction some valuable fragments. His passion for knowledge embraced all the sciences; but history, medals, antiquities, natural history, and particularly botany, were his favourite studies. He was consulted from all quarters, and the extent of his acquaintance with the learned world was very great. He corresponded with Justus Lipsius, Joseph Scaliger, Sigonius, Possevin, Peter Pithou, and a great many others, who have all paid the highest compliments to his erudition. Insensible to all the pleasures of life, and acquainted only with those of the mind, he had a great dislike to plays, entertainments, shows, and every thing which most excites the curiosity of other men. During the space of 43 years that he lived at Padua, he was never known to be out of the city but twice; once on occasion of a plague which infested it; and afterwards on a voyage to Naples, which he made at the earnest solicitation of his friends. In short, Pinelli was generous, Pinelli || Ping-leang-fou.

ous, sympathizing, and compassionate, particularly to men of letters, whose wants he often anticipated. His zeal for the progress and advancement of science rendered him very communicative of his knowledge and of his books; but this was always done with judgement and discretion. He died in 1601, aged 68, without having published any work. Paul Gualdo, who has written Pinelli's life, does not specify the number of volumes of which his rich library consisted: he only informs us, that when it was transported by sea to Naples, it was packed up in 130 chests, of which 14 contained manuscripts; but it did not go wholly to his heirs. The senate of Venice caused their seal to be set upon the manuscripts, and took away whatever concerned the affairs of the republic, to the number of 200 pieces.—"I compare (says President de Thou) Pinelli to Titus Pomponius; for, as that illustrious Roman was called *Attick*, Pinelli also bore the title of *Venetian*, on account of the great affection which the republic of Venice had for him.

PINET, Antony du, lord of Noroy, an ecclesiastical writer, lived in the 16th century, and was a native of Besançon. He was strongly attached to the Protestant religion, and a bitter enemy to the church of Rome. His book, entitled *La Conformité des Eglises Reformés de France*, and *de l'Eglise primitive*, printed at Lyons, 1564, in 8vo; and the notes which he added to the French translation of the Fees of the Pope's Chancery, which was printed at Lyons, in 8vo, 1564, and reprinted at Amsterdam in 1700, in 12mo, plainly discover his sentiments. He published the last-mentioned performance under this title: *Taxe des parties casuelles de la boutique du Pape*, in Latin and French, with some notes taken from decrees, councils, and canons, in order to ascertain the discipline anciently observed in the church. In the epistle dedicatory, he assumes the tone of a declared enemy to the court of Rome. He apologizes for having presented this book "to a society so holy as yours (the Protestants), in which are heard only hymns, psalms, and praises, to the Lord our God: but it is proper to show to the villain his villany, and the fool his folly, lest one should be thought to resemble them." We see by this specimen, that Pinet had no more politeness in his style than in his manners. His translation of Pliny's Natural History, printed at Lyons in 2 vol. folio, 1566, and at Paris, 1608, was formerly much read. Though there are a good many errors in it, it is yet very useful at present, especially for those who understand Pliny's Latin, on account of the translator's researches, and a great number of marginal notes. Pinet also published Plans of the principal fortresses in the world at Lyons, 1564, in folio.

Grosier's General Description of China, vol. i. p. 92.

PING-LEANG FOU, a city of China in the province of Chen-si. It is one of the most considerable cities of the western part of the province, and is situated on the river Kin-ho. The air here is mild; and the agreeable views which the surrounding mountains present, added to the streams which water the country, render it a very delightful residence. It has under its jurisdiction three cities of the second class and seven of the third. In this district is a valley so deep and narrow, that it is almost impervious to the light: a large highway, paved with square stones, runs through it.

Pinguicula || Pinnoterus.

PINGUICULA, Butterwort; a genus of plants belonging to the diandria class. See Botany *Index*.

PINGUIN, or Penguin, in *Ornithology*, a genus of birds of the order anseres. See Aptenodytes, Ornithology *Index*, or page 507.

PINION, in *Mechanics*, an arbor, or spindle, in the body whereof are several notches, which catch the teeth of a wheel that serves to turn it round; or it is a lesser wheel that plays in the teeth of a larger.

PINK, a name given to a ship with a very narrow stern; whence all vessels, however small, whose sterns are fashioned in this manner, are called *pink-sterned*.

Pink. See Dianthus, Botany *Index*.

PINNA, in *Zoology*, a genus of shell-fish belonging to the order of vermes testacea. See Conchology *Index*.—Pliny, who gives some account, perhaps not very correct, of the history of some of the species of this genus, (lib. ix. 51.) says, the smallest of all the kinds is called the *pinnoteres*, and therefore liable to injury; this has the prudence to hide itself in the shells of oysters. Again, lib. ix. 66. he says, the pinna is of the genus of shell-fish; it is produced in muddy waters, always erect, nor ever without a companion, which some call the *pinnoteres*, others the *pinnophylax*. This sometimes is a small squill, sometimes a crab, that follows the pinna for the sake of food. The pinna, upon opening its shell, exposes itself as a prey to the smallest kind of fishes; for they immediately assault her, and, growing bolder upon finding no resistance, venture in. The guard, watching its time, gives notice by a bite; upon which the pinna, closing its shell, shuts in, kills, and gives part of whatever happens to be there to its companion.

The pinna and the crab together dwell,
For mutual succour, in one common shell.
They both to gain a livelihood combine;
That takes the prey, when this has given the sign.
From hence this crab, above his fellows fam'd,
By ancient Greeks was *pinnoteres* nam'd.—Oppian.

PINNACE, a small vessel navigated with oars and sails, and having generally two masts, which are rigged like those of a schooner.

Pinnace is also a boat usually rowed with eight oars. See the article Boat.

PINNACLE, in *Architecture*, the top or roof of a house, terminating in a point. This kind of roof among the ancients was appropriated to temples; their ordinary roofs were all flat, or made in the platform way.

PINNATED leaves. See Botany *Index*.

PINNATIFID leaves. See Botany *Index*.

PINNOTERUS, or Pinnophylax, is a kind of crab-fish, furnished with very good eyes. It is said to be the companion of the pinna marina. They live and and lodge together in the same shell, which belongs to the latter. When it has occasion to eat, it opens its valves, and sends out its faithful purveyor to procure food. If during their labour the pinnoterus perceives the polypus, it immediately returns to warn its blind friend of the danger, when, by shutting its valves, it escapes the rage of its enemy; but when the pinnoterus loads itself with booty without molestation, it makes a gentle noise at the opening of the shell, and when admitted

mitted the two friends feast on the fruits of its industry. See PINNA, &c.

PINT (*pinta*), a vessel, or measure, used in estimating the quantity of liquids, and even sometimes of dry things.—Budæus derives the word from the Greek πινθα; others from the German *pint*, a little measure of wine; Nicod from the Greek πινειν, "to drink."

The *English pint* is twofold; the one for wine measure, the other for beer and ale measure. See MEASURE.

PINTADA, a species of PROCELLARIA.

PINTLES, certain pints or hooks fastened upon the back part of the rudder, with their points downwards, in order to enter into, and rest upon, the *googings*, fixed in the stern-post, to hang the rudder. See HELM.

PINTOR, PETER, physician, was born at Valentia in Spain, in the year 1420, and was physician to Alexander VI. whom he followed to Rome, where he practised with great success. He has left behind him two performances of considerable merit, 1. *Aggregator Sententiarum Doctorum de Curatione in Pestilentia*, printed at Rome 1499, in folio. 2. *De Morbo Fœdo et Occulto his Temporibus Affligenti*, &c. printed at Rome, 1500, in 4to, black letter: a book extremely scarce, unknown to Luisini and Astruc, and which traces the venereal disease to the year 1496. Pintor died at Rome in 1503, aged 83 years.

PINTURICCIO, BERNARDINO, a celebrated Italian painter, was born at Perusia in 1454. He was the disciple of Peter Perugino, under whom he became so good an artist, that he employed him on many occasions as his assistant. He principally painted history and grotesque; but he also excelled in portraits, among which those of Pope Pius II. and Innocent VIII. of Giulia Farnese, Cæsar Borgia, and Queen Isabella of Spain, are particularly distinguished. The most memorable performance of Pinturiccio is the history of Pius II. painted in ten compartments in the monastery of Siena; in which undertaking, Raphael, then a young man, and bred under the same master, assisted him so far as to sketch out cartoons of many parts of the composition. The story of his death is worth relating, especially as it illustrates his character. The last work he was engaged in was a *Nativity* for the monastery of St Francis at Siena: the monks accommodated him with a chamber to work in, which they cleared of all the furniture, except one old trunk or chest that appeared too rotten to move; but Pinturiccio, naturally positive and peevish, insisted on its being taken away, and the monks, willing to gratify him, complied. It was no sooner stirred than one of the planks bursting, out tumbled 500 pieces of gold, which had been secreted there for many years. The monks were overjoyed at finding this treasure, and the painter proportionably mortified at losing his chance of the discovery by his indiscreet obstinacy: it affected his spirits so much that he survived but a few months, and it was generally considered as the cause of his death.

PINUS, the PINE-TREE; a genus of plants belonging to the monœcia class. See BOTANY *Index*. The pine-tree was well known to the ancients, and has been described and celebrated both by their philosophers and poets. Pliny enumerates no less than six species of trees of this genus; and it is mentioned by Virgil both in his Eclogues, his Georgics, and his Æneid; by Horace in his Odes; by Ovid in his Metamorphoses; by Statius; and by Catullus, &c. Macrobius relates an anecdote concerning the cones of pine-trees, which in common language were called *poma pinea*, "pine-apples." There lived in the Augustan age one Vatinius, who by some means had irritated the Roman people so much that they pelted him with stones. When he entertained them with gladiators, to save himself from such treatment for the future, he procured an edict from the ediles, that no person should throw any thing but apples in the amphitheatre. It accidentally happened that at this time Cascellius, eminent for his wit as well as knowledge of the law, was consulted on the question, whether a pine-apple (the cone of the pine) was legally included in the term *pomum*, "an apple?" It is an apple (said he) if you intend to fling it at Vatinius*. A decision by which the edict in his favour did not much mend his situation: for Martial represents it dangerous to come under this tree, because the cones in his time were of so great a size and weight, probably enlarged by cultivation for ages.

* *Saturn.* lib. ii. cap. 6.

Nuces Pineæ.

Poma sumus Cybeles: procul hinc discede, viator,
Ne cadat in miserum nostra ruina caput †.

† Lib. xiii. Ep. 25.

There are generally reckoned 14 species of this genus; of which the most remarkable are these following:

1. The *pinea*, *pineaster*, or wild pine, grows naturally on the mountains in Italy and the south of France. It grows to the size of a large tree; the branches extend to a considerable distance; and while the trees are young, they are fully garnished with leaves, especially where they are not so close as to exclude the air from those within; but as they advance in age, the branches appear naked, and all those which are situated below become unsightly in a few years; for which reason they are now much less in esteem than formerly.

2. The *pinus pinea*, or stone pine, is a tall evergreen tree, native of Italy and Spain. It delights in a sandy loam, though like most others it will grow well in almost any land. Respecting the uses of this species, Hanbury tells us that "the kernels are eatable, and by many preferred to almonds. In Italy they are served up at table in their desserts.—They are exceeding wholesome, being good for coughs, colds, consumptions, &c. on which account only this tree deserves to be propagated." Hanbury continues: "It may be very proper here to take notice of a very great and dangerous mistake Mr Miller has committed, by saying, under this article of stone-pine, that seeds kept in the cones will be good, and grow if they are sown ten or twelve years after the cones have been gathered from the trees; whereas the seeds of this sort, whether kept in the cones or taken out, are never good after the first year; and though sometimes a few plants will come up from the seeds that are kept in the cones for two years before, yet this is but seldom; neither must a tenth part of a crop be expected. This caution is the more necessary, as several gentlemen who had cones, upon reading Mr Miller's book, and finding the seeds would take no damage when kept there, deferred the work for a season or two, when they thought they should have more conveniency either of men or ground for their purpose; and were afterwards wholly disappointed, no plants appearing,

Pinus.

pearing, the feeds being by that time fpoiled and worth nothing."

3. The *rubra*, commonly called the *Scots fir* or *pine*. It is common throughout Scotland, whence its name; though it is alfo found in moft of the other countries of Europe. M. du Hamel, of the Royal Academy of Sciences, mentions his having received fome feeds of it from St Domingo in the Weft Indies; and thence concludes, that it grows indifferently in the temperate, frigid, and torrid zones. The wood of this tree is the red or yellow deal, which is the moft durable of any of the kinds yet known. The leaves of this tree are much fhorter and broader than thofe of the former fort, of a grayifh colour, growing two out of one fheath; the cones are fmall, pyramidal, and end in narrow points; they are of a light colour, and the feeds are fmall.

4. The *pinus picea*, or yew-leaved fir, is a tall evergreen, and a native of Scotland, Sweden, and Germany. This fpecies includes the filver fir and the balm of Gilead fir. The firft of thefe is a noble upright tree. Mr Marfham fays, "The talleft trees I have feen were fpruce and filver firs in the valleys in Switzerland. I faw feveral firs in the dockyards in Venice 40 yards long; and one of 39 yards was 18 inches diameter at the fmall end. I was told they came from Switzerland."

Treatife on Planting and Ornamental Gardening.

The branches are not very numerous, and the bark is fmooth and delicate. The leaves grow fingly on the branches, and their ends are flightly indented. Their upper furface is of a fine ftrong green colour, and their under has an ornament of two white lines running lengthwife on each fide the midrib; on account of which filvery look this fort is called the *filver fir*. The cones are large, and grow erect; and, when the warm weather comes on, they foon fhed their feeds; which fhould be a caution to all who wifh to raife this plant, to gather the cones before that happens.

The balm of Gilead fir has of all the forts been moft coveted, on account of the great fragrance of its leaves; though this is not its only good property: for it is a very beautiful tree, naturally of an upright growth, and the branches are fo ornamented with their balmy leaves, as to exceed any of the other forts in beauty. The leaves, which are very clofely fet on the branches, are broad; and their ends are indented. Their upper furface, when healthy, is of a fine dark-green colour, and their under has white lines on each fide the midrib lengthwife, nearly like thofe of the filver fir. Thefe leaves when bruifed are very finely fcented; and the buds, which fwell in the autumn for the next year's fhoot, are very ornamental all winter, being turgid, and of a fine brown colour: and from thefe alfo exudes a kind of fine turpentine, of the fame kind of (though heightened) fragrancy. The tree being wounded in any part, emits plenty of this turpentine; and Hanbury fays, "it is fuppofed by many to be the fort from whence the balm of Gilead is taken, which occafions this tree being fo called. But this is a miftake; for the true balm of Gilead is taken from a kind of terebinthus: though I am informed, that what has been collected from this tree has been fent over to England from America (where it grows naturally), and often fold in the fhops for the true fort."

The filver fir is very hardy, and will grow in any foil or fituation, but always makes the greateft progrefs in rich loamy earth. The balm of Gilead fir muft be planted in deep, rich, good earth; nor will it live long in any other. The foil may be a black mould, or of a fandy nature, if it be deep enough, and if the roots have room enough to ftrike freely.

Pinus.

5. The *pinus abies*, or European fpruce fir, a native of the northern parts of Europe and of Afia, includes the Norway fpruce and long-coned Cornifh fir. The former of thefe is a tree of as much beauty while growing as its timber is valuable when propagated on that account. Its growth is naturally like the filver, upright: and the height it will afpire to may be eafily conceived, when we fay that the white deal, fo much coveted by the joiners, &c. is the wood of this tree; and it may perhaps fatisfy the curious reader to know, that from this fir pitch is drawn. The leaves are of a dark-green colour; they ftand fingly on the branches, but the younger fhoots are very clofely garnifhed with them. They are very narrow; their ends are pointed; and they are poffeffed of fuch beauties as to excite admiration. The cones are eight or ten inches long, and hang downwards.

Ibid.

The better the foil is, the fafter will the fpruce fir grow, though it will thrive very well in moft of our Englifh lands. In ftrong loamy earth it makes a furprifing progrefs; and it delights in frefh land of all forts, which never has been worn out by ploughing, &c. though it be ever fo poor. The long-coned Cornifh fir differs fcarcely in any refpect from the Norway fpruce, except that the leaves and the cones are larger.

6. The *pinus Canadenfis*, American or Newfoundland fpruce fir, a native of Canada, Pennfylvania, and other parts of North America, includes three varieties. The white Newfoundland fpruce, the red Newfoundland fpruce, and the black Newfoundland fpruce. Thefe, however, differ fo little, that one defcription is common to them all. They are of a genteel upright growth, though they do not fhoot fo freely or grow fo faft with us as the Norway fpruce. The leaves are of the fame green, and garnifh the branches in the fame beautiful manner as thofe of that fpecies; only they are narrower, fhorter, and ftand clofer. The greateft difference is obfervable in the cones; for thefe are no more than about an inch in length, and the fcales are clofely placed. In the cones, indeed, confifts the difference of thefe three forts: thofe of the white fpecies are of a very light brown colour; thofe of the red fpecies more of a nut-brown or reddifh colour; and thofe of the black fpecies of a dark or blackifh colour. Befides this, there is fcarcely any material difference; though it is obfervable, that this trifling variation feems to be pretty conftant in the plants raifed from the like feeds. Thefe forts will often flower, and produce cones when only about five or fix feet high; and indeed look then very beautiful: but this is a fign of weaknefs in the plant, which it does not often fairly get over.

7. The *pinus balfamea*, or hemlock fir, a native of Virginia and Canada, poffeffes as little beauty as any of the fir tribe; though, being rather fcarce in proportion, it is deemed valuable. It is called by fome the *yew-leaved fir*, from the refemblance of the leaves to thofe of the yew-tree. It is a tree of low growth, with but few branches; and thefe are long and flender, and fpread abroad without order. The leaves do not garnifh the branches

Pinus. branches so plentifully as those of any other sort of fir. The cones are very small and rounded; they are about half an inch long; and the scales are loosely arranged. We receive these cones from America, by which we raise the plants; though this caution should be given to the planter, that this tree is fond of moist rich ground, and in such a kind of soil will make the greatest progress.

8. The *pinus orientalis*, or oriental fir, a native of the East, is a low but elegant tree. The leaves are very short, and nearly square. The fruit is exceeding small, and hangs downward; and the whole tree makes an agreeable variety with the other kinds.

9. The *strobus*, Lord Weymouth's pine, or North American white pine. This grows sometimes to the height of 100 feet and upwards, and is highly valued on account of its beauty. The bark of the tree is very smooth and delicate, especially when young; the leaves are long and slender, five growing out of one sheath; the branches are pretty closely garnished with them, and thus make a fine appearance. The cones are long, slender, and very loose, opening with the first warmth of the spring; so that if they are not gathered in winter, the scales open and let out the seeds. The wood of this sort is esteemed for making masts for ships. In Queen Anne's time there was a law made for the preservation of these trees, and for the encouragement of their growth in America. Within these last 50 years they have been propagated in Britain in considerable plenty.

With respect to the culture of this species, Mr Hanbury, after some more general directions, continues thus, "I have known gentlemen, who, in attempting to raise these trees, have seen the young plants go off without perceiving the cause; and the more watering and pains they have taken, have found the plants persist in this way more and more, to their great mortification and astonishment. In the spring following these plants should be pricked out in beds half a foot asunder each way; and here they may stand two years, when they may be either finally planted out, or removed into the nursery, at the distance of one foot asunder, and two feet in the rows. If care has been taken of them in the nursery, they may be removed at a considerable height with great assurance of success: for it is much easier to make this pine grow than any of the other sorts: so that where they are wanted for ornament in parks, open places, &c. a show of them may be made in a little time.

"The soil the Weymouth pine delights in most is a sandy loam; but it likes other soils of an inferior nature: and although it is not generally to be planted on all lands like the Scotch fir, yet I have seen it luxuriant and healthy, making strong shoots, on blue and red clays, and other sorts of strong ground. On stony and slaty ground, likewise, I have seen some very fine trees; so that I believe whoever is desirous of having plantations of this pine, need not be curious in the choice of his ground."

10. The *pinus tæda*, or swamp-pine, is a tall evergreen tree, a native of the swamps of Virginia and Canada. There are several varieties of this genus which Hanbury enumerates and describes: such as, 1st, The three-leaved American swamp-pine. 2d, The two-leaved American pine. 3d, The yellow American pine, the yellow tough pine, and the tough pine of the plains; among which there is but little variety. 4th, The bastard pine. 5th, The frankincense pine. And 6th, The dwarf pine. Pinus.

"There are (continues our author) many other sorts of American pines, which we receive from thence with the like cant names of those of the above, which I have chosen to retain, as they will probably be continued to be sent over; and that the gardener receiving them as such may best know what to do with them. In many of those sorts I see at present no material difference; so am induced to think they are the same, sent over with different names. Some of the sorts above-mentioned differ in very few respects; but I have chosen to mention them, as a person may be supplied with the seeds from Pennsylvania, Jersey, Virginia, Carolina, &c. where they all grow naturally: and having once obtained the seeds, and from them plants, they will become pleasing objects of his nicest observations."

11. The *pinus cedrus*, ranked by Tournefort and others under larix, famous for its duration, is that popularly called by us the *cedar of Lebanon*, by the ancients *cedrus magna* or the *great cedar*; also *cedrelate*, *κεδρελατη*; and sometimes the Phœnician or Syrian cedar, from the country where it grows in its greatest perfection. It is a coniferous evergreen, of the bigger sort, bearing large roundish cones of smooth scales, standing erect, the leaves being small, narrow, and thick set.—They sometimes counterfeit cedar, by dyeing wood of a reddish hue: but the smell discovers the cheat, that of true cedar being very aromatic. In some places, the wood of the cajou-tree passes under the name of cedar, on account of its reddish colour and its aromatic smell, which somewhat resemble that of santal. Cedar-wood is reputed almost immortal and incorruptible; a prerogative which it owes chiefly to its bitter taste, which the worms cannot endure. For this reason it was that the ancients used cedar tablets to write upon, especially for things of importance, as appears from that expression of Persius, *Et cedra digna locutus*. A juice was also drawn from cedar, with which they smeared their books and writings, or other matters, to preserve them from rotting; which is alluded to by Horace: by means of which it was, that Numa's books, written on papyrus, were preserved entire to the year 535, as we are informed by Pliny.

Solomon's temple, as well as his palace, were both of this wood. That prince gave King Hiram several cities for the cedars he had furnished him on these occasions. Cortes is said to have erected a palace at Mexico, in which were 7000 beams of cedar, most of them 120 feet long, and 12 in circumference, as we are informed by Herrera. Some tell us of a cedar felled in Cyprus 130 feet long, and 18 in diameter. It was used for the main-mast in the galley of King Demetrius. Le Bruyn assures us, that the two biggest he saw on Mount Lebanon, measured, one of them 57 palms, and the other 47, in circumference. In the temple of Apollo at Utica, there were cedar trees near 2000 years old; which yet were nothing to that beam in an oratory of Diana at Seguntum in Spain, said to have been brought thither 200 years before the destruction of Troy. Cedar is of so dry a nature, that it will not endure to be fastened with iron nails, from which it usually shrinks; so that they commonly fasten it with pins of the same wood.

"The

Pinus.

"The ſtatue (ſays Hanbury) of the great goddeſs at Epheſus was made of this material; and, if this tree abounded with us in great plenty, it might have a principal ſhare in our moſt ſuperb edifices. The effluvia conſtantly emitted from its wood are ſaid to purify the air, and make rooms wholeſome. Chapels and places ſet apart for religious duties, being wainſcotted with this wood, inſpire the worſhippers with a more ſolemn awe. It is not obnoxious to worms; and emits an oil which will preſerve cloth or books from worms or corruption. The ſaw-duſt will preſerve human bodies from putrefaction; and is therefore ſaid to be plentifully uſed in the rites of embalming, where practiſed."

It is remarkable that this tree is not to be found as a native in any other part of the world than Mount Libanus, as far as hath yet been diſcovered. What we find mentioned in Scripture of the lofty cedars can be nowiſe applicable to the common growth of this tree; ſince, from the experience we have of thoſe now growing in England, as alſo from the teſtimony of ſeveral travellers who have viſited thoſe few remaining trees on Mount Libanus, they are not inclined to grow very lofty, but on the contrary extend their branches very far; to which the alluſion made by the Pſalmiſt agrees very well, when he is deſcribing the flouriſhing ſtate of a people, and ſays, "They ſhall ſpread their branches like the cedar-tree."

Rauwolf, in his Travels, ſays, there were not at that time (i. e. anno 1574) upon Mount Libanus more than 26 trees remaining, 24 of which ſtood in a circle; and the other two, which ſtood at a ſmall diſtance, had their branches almoſt conſumed with age; nor could he find any younger tree coming up to ſucceed them, though he looked about diligently for ſome. Theſe trees (he ſays) were growing at the foot of a ſmall hill, on the top of the mountains, and amongſt the ſnow. Theſe having very large branches, commonly bend the tree to one ſide, but are extended to a great length, and in ſo delicate and pleaſant order, as if they were trimmed and made even with great diligence, by which they are eaſily diſtinguiſhed, at a great diſtance, from fir-trees. The leaves (continues he) are very like to thoſe of the larch-tree, growing cloſe together in little branches upon ſmall brown ſhoots.

Maundrel, in his Travels, ſays, there were but 16 large trees remaining when he viſited the mountain, ſome of which were of a prodigious bulk, but that there were many more young ones of a ſmaller ſize: he meaſured one of the largeſt, and found it to be 12 yards ſix inches in girth, and yet ſound, and 37 yards in the ſpread of its boughs. At about five or ſix yards from the ground it was divided into five limbs, each of which was equal to a great tree. What Maundrel hath related was confirmed by a gentleman who was there in the year 1720, with this difference only, viz. in the dimenſions of the branches of the largeſt tree, which he meaſured, and found to be 22 yards diameter. Now, whether Mr Maundrel meant 37 yards in circumference of the ſpreading branches, or the diameter of them, cannot be determined by his words; yet either of them well agrees with this laſt account.

Pinus.

12. There is another ſpecies, viz. the *larch-tree*, which the old botaniſts ranked under larix, with deciduous leaves, and oval obtuſe cones. It grows naturally upon the Alps and Apennines, and of late has been very much propagated in Britain. It is of quick growth, and the trunk riſes to 50 feet or more; the branches are ſlender, their ends generally hanging downward, and are garniſhed with long narrow leaves which ariſe in cluſters from one point, ſpreading open above like the hairs of a painter's bruſh: they are of a light green, and fall away in autumn. In the month of April the male flowers appear, which are diſpoſed in form of ſmall cones; the female flowers are collected into oval obtuſe cones, which in ſome ſpecies have bright purple tops, and in others they are white: theſe differences are accidental; the cones are about an inch long, obtuſe at their points; the ſcales are ſmooth, and lie over each other: under each ſcale there are generally lodged two ſeeds, which have wings. There are other two varieties of this tree, one of which is a native of America, and the other of Siberia. The cones of the American kind which have been brought to Britain ſeem in general to be larger than thoſe of the common ſort.

"Many encomiums (ſays Hanbury when ſpeaking of this ſpecies) have been beſtowed on the timber of the larch: and we find ſuch a favourable account of it in ancient authors, as ſhould induce us to think it would be proper for almoſt any uſe. Evelyn recites a ſtory of Witſen, a Dutch writer, that a ſhip built of this timber and cypreſs had been found in the Numidian ſea, twelve fathoms under water, ſound and entire, and reduced to ſuch a hardneſs as to reſiſt the ſharpeſt tool, after it had lain ſubmerged above 1400 years. Certain it is this is an excellent wood for ſhip and houſe-building. At Venice this wood is frequently uſed in building their houſes, as well as in Switzerland, where theſe trees abound: ſo that, without all doubt, the larch excels for maſts for ſhips, or beams for houſes, doors, windows, &c. particularly as it is ſaid to reſiſt the worm.

"In Switzerland (A) their houſes are covered with boards of this wood cut out a foot ſquare; and, as it emits a reſinous ſubſtance, it ſo diffuſes itſelf into every joint and crevice, and becomes ſo compact and cloſe, as well as ſo hardened by the air, as to render the covering proof againſt all weather. But as ſuch covering for houſes would cauſe great devaſtation in caſe of fire, the buildings

(A) "Between Bex and Bevieux (ſays Coxe in his *Travels in Switzerland*), I obſerved the larch in great plenty. Painters, from the time of Pliny to that of Raphael, truſted their works to this wood, which the Roman naturaliſt ſtiles *immortale lignum*. The wood is reckoned excellent for all works which are to lie under water: and the borderers on the lake of Geneva prefer it for building their veſſels. In theſe parts I ſaw moſt beautiful woods of cheſnut. Haller ſays that they extend ſome leagues: he alſo informs us, that they are found in other parts of Switzerland, and even in deſert places in ſome of the tranſalpine parts. Accident muſt have brought them thither, as it appears from Pliny that theſe trees were firſt introduced into Europe from Sardis."

Pinus. buildings are confined to a limited distance by an order of police from the magistrates. The wood when first laid on the houses, is said to be very white; but this colour, in two or three years is changed, by means of the sun and resin, to a black, which appears like a smooth shining varnish."

Of the common larch there are several varieties. The flowers which the commonest sort exhibits early in the spring are of a delicate red colour; another sort produces white flowers at the same season, and these have a delightful effect among those of the red sort; whilst another, called the *Black Newfoundland larix*, increases the variety, though by an aspect little differing from the others. There are also larches with greenish flowers, pale red, &c. all of which are accidental varieties from seeds. These varieties are easily distinguished, even when out of blow: the young shoots of the white-flowering larch are of the lightest green, and the cones when ripe are nearly white. The red flowering larch has its shoots of a reddish cast, and the cones are of a brown colour; whilst the cones and shoots of the black Newfoundland larch are in the same manner proportionally tinged. The cones, which are a very great ornament to several sorts of the pines, are very little to these. Their chief beauty consists in the manner of their growth, the nature and beauty of their pencilled leaves and fair flowers; for the cones that succeed them are small, of a whitish, a reddish, or a blackish-brown colour, and make no figure.

The pinus cedrus and pinus larix are propagated by sowing in March on a bed of light earth exposed to the morning sun. The seed must be covered half an inch thick with fine light earth, and the beds watered at times when the weather is dry. In about six weeks the plants will appear; they must at this time be carefully guarded from the birds, shaded from the sun and winds, and kept very clear of weeds. In the latter end of April the following year, they may be removed into beds of fresh earth, placing them at ten inches distance every way. They are to be kept here two years, and such of them as seem to bend must be tied up to a stake to keep them upright. They may afterwards be planted in the places where they are to remain. They thrive well on the sides of barren hills, and make a very pretty figure there.

Respecting the uses of this tree, Dr Pallas, in his *Flora Rossica*, informs us, that if it is burnt, and the wood consumed, the internal part of the wood distils copiously a drying reddish gum, a little less glutinous than gum arabic, somewhat of a resinous taste, but wholly soluble in water. At the instigation of M. Kinder, this gum has lately been sold in the Russian shops under the name of *gummi Orenburgensis*, but which our author thinks should be called *gummi Uraliense* or *laricis*. It is eaten by the Woguli as a dainty, and is said to be nutritious and antiscorbutic. Some manna was gathered from the green leaves, but it could never be condensed. The Russians use the boletus laricinus as an emetic in intermittents, and to check the leucorrhœa. At Baschir and Siberia the inhabitants sprinkle the dry powder on the wounds of oxen and horses, as a detergent and anthelmintic. The nuts of the pinus cembra, the same author asserts, are eaten as luxuries in Russia, and are even exported with the same view. The unripe cones give a very fragrant oil, termed balsamic. The inhabitants of Siberia use the tender tops, and even the bark rubbed off in the spring, as an antiscorbutic. The kernels of the nuts of the amygdalus nana give a very pleasing flavour to brandy; and, when pressed, afford a bitter oil in large quantities. The way of destroying the bitter is by digesting it in the sun with spirit of wine, and it then becomes sweet and extremely agreeable.

From the larch-tree is extracted what is erroneously called *Venice turpentine*. This substance, or natural balsam, flows at first without incision; when it has done dropping, the poor people who wait in the fir woods make incisions at about two or three feet from the ground into the trunks of the trees, into which they fix narrow troughs about 20 inches long. The end of these troughs is hollowed like a ladle; and in the middle is a small hole bored for the turpentine to run into the receiver which is placed below it. As the gummy substance runs from the trees, it passes along the sloping gutter or trough to the ladle, and from thence runs through the holes into the receiver. The people who gather it visit the trees morning and evening from the end of May to September, to collect the turpentine out of the receivers. When it flows out of the tree, Venice turpentine is clear like water, and of a yellowish white; but, as it grows older, it thickens and becomes of a citron colour. It is procured in the greatest abundance in the neighbourhood of Lyons, and in the valley of St Martin near St Lucern in Switzerland.

Though we have already noticed the manner of cultivating some of the particular species of this genus, and have also remarked the uses of some of them, we shall finish the article with a few general observations on the culture and uses of the whole.

Culture. All the sorts of pines are propagated by seeds produced in hard woody cones. The way to get the seeds out of these cones is to lay them before a gentle fire, which will cause the cells to open, and then the seeds may be easily taken out. If the cones are kept entire, the seeds will remain good for some years; so that the surest way of preserving them is to let them remain in the cones till the time for sowing the seeds. If the cones are kept in a warm place in summer, they will open and emit the seeds; but if they are not exposed to the heat, they will remain close for a long time. The best season for sowing the pines is about the end of March. When the seeds are sown, the place should be covered with nets to keep off the birds; otherwise, when the plants begin to appear with the husk of the seed on the top of them, the birds will peck off the tops, and thus destroy them.

Uses. From the first species is extracted the common turpentine, much used by farriers, and from which is drawn the oil of that name. The process of making pitch, tar, resin, and turpentine, from these trees, is very familiar. In the spring time, when the sap is most free in running, they pare off the bark of the pine tree, to make the sap run down into a hole which they cut at the bottom to receive it. In the way, as it runs down, it leaves a white matter like cream, but a little thicker. This is very different from all the kinds of resin and turpentine in use, and it is generally sold to be used in the making of flambeaux instead of white bees wax. The matter that is received in the hole at the bottom is taken up with ladles, and put in a large basket. A great part of this immediately runs through, and this is the common

mon turpentine. This is received into ſtone or earthen pots, and is ready for ſale. The thicker matter, which remains in the baſket, they put into a common alembic, adding a large quantity of water. They diſtil this as long as any oil is ſeen ſwimming upon the water. This oil they ſeparate from the ſurface in large quantities, and this is the common oil or ſpirit of turpentine. The remaining matter at the bottom of the ſtill is common yellow reſin. When they have thus obtained all that they can from the ſap of the tree, they cut it down, and hewing the wood into billets, they fill a pit dug in the earth with theſe billets, and, ſetting them on fire, there runs from them, while they are burning, a black thick matter. This naturally falls to the bottom of the pit, and this is the tar. The top of the pit is covered with tiles, to keep in the heat; and there is at the bottom a little hole, out at which the tar runs like oil. If this hole be made too large, it ſets the whole quantity of the tar on fire; but, if ſmall enough, it runs quietly out.

The tar, being thus made, is put up in barrels; and if it be to be made into pitch, they put it into large boiling veſſels, without adding any thing to it. It is then ſuffered to boil a while, and being then let out, is found when cold to be what we call pitch.

A decoction of the nuts or ſeeds of the firſt ſpecies in milk, or of the extremities of the branches pulled in ſpring, is ſaid, with a proper regimen, to cure the moſt inveterate ſcurvy. The wood of this ſpecies is not valued; but that of the Scots pine is ſuperior to any of the reſt. It is obſervable of the Scots pine, that when planted in bogs, or in a moiſt ſoil, though the plants make great progreſs, yet the wood is white, ſoft, and little eſteemed; but when planted in a dry ſoil, though the growth of the trees is there very ſlow, yet the wood is proportionably better. Few trees have been applied to more uſes than this. The talleſt and ſtraigheſt are formed by nature for maſts to our navy. The timber is reſinous, durable, and applicable to numberleſs domeſtic purpoſes, ſuch as flooring and wainſcotting of rooms, making of beds, cheſts, tables, boxes, &c. From the trunk and branches of this, as well as moſt others of the pine tribe, tar and pitch is obtained. By inciſion, barras, Burgundy pitch, and turpentine, are acquired and prepared. The reſinous roots are dug out of the ground in many parts of the Highlands, and, being divided into ſmall ſplinters, are uſed by the inhabitants to burn, inſtead of candles.—At Loch-Broom, in Roſs-ſhire the fiſhermen make ropes of the inner bark; but hard neceſſity has taught the inhabitants of Sweden, Lapland, and Kamtſchatka, to convert the ſame into bread. To effect this, they, in the ſpring ſeaſon, make choice of the talleſt and faireſt trees; then ſtripping off carefully the outer bark, they collect the ſoft, white, ſucculent interior bark, and dry it in the ſhade. When they have occaſion to uſe it, they firſt toaſt it at the fire, then grind, and after ſteeping the flour in warm water to take off the reſinous taſte, they make it into thin cakes, which are baked for uſe. On this ſtrange food the poor inhabitants are ſometimes conſtrained to live for a whole year; and, we are told, through cuſtom, become at laſt even fond of it. Linnæus remarks, that this ſame bark-bread will fatten ſwine; and humanity obliges us to wiſh, that men might never be reduced to the neceſſity of robbing them of ſuch a food. The interior bark, of which the above-mentioned bread is made, the Swediſh boys frequently peel off the trees in the ſpring, and eat raw with greedy appetite. From the cones of this tree is prepared a diuretic oil, like the oil of turpentine, and a reſinous extract, which has ſimilar virtues with the balſam of Peru. An infuſion or tea of the buds is highly commended as an antiſcorbutic. The farina, or yellow powder, of the male-flowers, is ſometimes in the ſpring carried away by the winds, in ſuch quantities, where the trees abound, as to alarm the ignorant with the notion of its raining brimſtone. The tree lives to a great age; Linnæus affirms to 400 years.

PIONEERS, in the art of war, are ſuch as are commanded in from the country, to march with an army for mending the ways, for working on intrenchments and fortifications, and for making mines and approaches. The ſoldiers are likewiſe employed for all theſe purpoſes. Moſt of the foreign regiments of artillery have half a company of pioneers, well inſtructed in that important branch of duty. Our regiments of infantry and cavalry have three or four pioneers each, provided with aprons, hatchets, ſaws, ſpades, and pick-axes. Each pioneer muſt have an axe, a ſaw, and an apron; a cap with a leather crown, and a black bears-ſkin front, on which is to be the king's creſt in white, on a red ground; and the number of the regiment is to be on the back part of it.

PIP, or PEP, a diſeaſe among poultry, conſiſting of a white thin ſkin, or film, that grows under the tip of the tongue, and hinders their feeding. It uſually ariſes from want of water, or from the drinking puddle-water, or eating filthy meat. It is cured by pulling off the film with the fingers, and rubbing the tongue with ſalt. Hawks are particularly liable to this diſeaſe, eſpecially from feeding on ſtinking fleſh.

PIPE, in building, &c. a canal, or conduit, for the conveyance of water and other liquids. Pipes for water, water-engines, &c. are uſually of lead, iron, earth, or wood: the latter are uſually made of oak or elder. Thoſe of iron are caſt in forges; their uſual length is about two feet and a half: ſeveral of theſe are commonly faſtened together by means of four ſcrews at each end, with leather or old hat between them, to ſtop the water. Thoſe of earth are made by the potters; theſe are fitted into one another, one end being always made wider than the other. To join them the cloſer, and prevent their breaking, they are covered with tow and pitch: their length is uſually about that of the iron pipes. The wooden pipes are trees bored with large iron augres, of different ſizes, beginning with a leſs, and then proceeding with a larger ſucceſſively; the firſt being pointed, the reſt being formed like ſpoons, increaſing in diameter, from one to ſix inches or more: they are fitted into the extremities of each other (as repreſented fig. 2.), and are ſold by the foot.

Wooden pipes are bored as follows. The machine repreſented fig. 1. is put in motion by the wheel A, which is moved by a current of water; upon the axle of this wheel is a cog-wheel B, which cauſes the lanterns C, D, to turn horizontally, whoſe common axis is conſequently in a perpendicular direction. The lantern D turns at the ſame time two cog-wheels, E and F: the firſt, E, which is vertical, turns the augre which bores the wood; and the ſecond, F, which is horizontal, cauſes the carriage bearing the piece to advance by means of the arms H, I, which take hold of the notches in the wheel K. The firſt, H, by means of the notches, draws the wheel towards F; and the other, I, puſhes the under-poſt of the wheel in an oppoſite direction; both which motions tend to draw the carriage towards F, and conſequently cauſe the augre to pierce the wood. The augre being from 9 to 12 feet in length, and of a proportionable bigneſs, it will be neceſſary to have two pieces, as L, L, to ſupport its weight, and cauſe it to enter the piece to be bored with the ſame uniformity.

For the conſtruction of leaden pipes, ſee the article PLUMBERY.

Air-PIPES. See *AIR-Pipes.*

PIPES of an Organ. See ORGAN.

Bag-PIPE. See *BAG-Pipe.*

Horn-PIPE. See HORNPIPE.

Tobacco-PIPE, a machine uſed in the ſmoking of tobacco, conſiſting of a long tube, made of earth or clay, having at one end a little caſe, or furnace, called the *bowl*, for the reception of the tobacco, the fumes whereof are drawn by the mouth through the other end. Tobacco pipes are made of various faſhions; long, ſhort, plain, worked, white, varniſhed, unvarniſhed, and of various colours, &c. The Turks uſe pipes three or four feet long, made of ruſhes, or of wood bored, at the end whereof they fix a kind of a pot of baked earth, which ſerves as a bowl, and which they take off after ſmoking.

PIPE, alſo denotes a veſſel or meaſure for wine, and things meaſured by wine-meaſure. See BARREL and MEASURE.

PIPE, in *Mining*, is where the ore runs forwards endwiſe in a hole, and doth not ſink downwards or in a vein.

PIPE, *Pipa*, in *Law*, is a roll in the exchequer, called alſo the *great roll*. See the next article.

PIPE-Office, is an office wherein a perſon called the *clerk of the pipe*, makes out leaſes of crown-lands, by warrant from the lord-treaſurer, or commiſſioners of the treaſury, or chancellor of the exchequer. The clerk of the pipe makes out alſo all accounts of ſheriffs, &c. and gives the accountants their *quietus eſt*. To this office are brought all accounts which paſs the remembrancer's office, and remain there, that if any ſtated debt be due from any perſon, the ſame may be drawn down into the great roll of the pipe: upon which the comptroller iſſues out a writ, called the *ſummons of the pipe*, for recovery thereof; and if there be no goods or chattels, the clerk then draws down the debts to the lord treaſurer's remembrancer, to write eſtreats againſt their lands. All tallies which vouch the payment of any ſum contained in ſuch accounts are examined and allowed by the chief ſecondary of the pipe. Beſides the chief clerk in this office, there are eight attorneys or ſworn clerks, and a comptroller.

PIPE-Fiſh. See SYNGNATHUS, ICHTHYOLOGY *Index.*

Sea PIPES, the trivial name of univalve ſhells belonging to the genus *dentalis*. See CONCHOLOGY *Index.*

PIPER, a ſpecies of fiſh. See TRIGLA, ICHTHYOLOGY *Index.*

PIPER, *Pepper;* a genus of plants belonging to the diandria claſs. See BOTANY *Index*. There are 20 ſpecies, of which the moſt remarkable is the ſiriboa, with oval, heart-ſhaped, nerved leaves, and reflexed ſpikes. This is the plant which produces the pepper ſo much uſed in food. It is a ſhrub whoſe root is ſmall, fibrous, and flexible; it riſes into a ſtem, which requires a tree or prop to ſupport it. Its wood has the ſame ſort of knots as the vine; and when it is dry, it exactly reſembles the vine-branch. The leaves, which have a ſtrong ſmell and a pungent taſte, are of an oval ſhape; but they diminiſh towards the extremity, and terminate in a point. From the flower-buds, which are white, and are ſometimes placed in the middle and ſometimes at the extremity of the branches, are produced ſmall berries reſembling thoſe of the currant tree. Each of theſe contains between 20 and 30 corns of pepper; they are commonly gathered in October, and expoſed to the ſun ſeven or eight days. The fruit which was green at firſt, and afterwards red, when ſtripped of its covering aſſumes the appearance it has when we ſee it. The largeſt, heavieſt, and leaſt ſhrivelled, is the beſt.

The pepper plants flouriſhes in the iſland of Java, Sumatra (A), and Ceylon, and more particularly on the Malabar coaſt. It is not ſown, but planted; and great nicety is required in the choice of the ſhoots. It produces no fruit till the end of three years; but bears ſo plentifully the three ſucceeding years, that ſome plants yield between ſix and ſeven pounds of pepper. The bark then begins to ſhrink; and the ſhrub declines ſo faſt, that in 12 years time it ceaſes bearing.

The culture of pepper is not difficult: it is ſufficient to plant it in a rich ſoil, and carefully to pull up the weeds that grow in great abundance round its roots, eſpecially the three firſt years. As the ſun is highly neceſſary to the growth of the pepper plant, when it is ready to bear, the trees that ſupport it muſt be lopped to prevent their ſhade from injuring the fruit. When the ſeaſon is over, it is proper to crop the head of the plant. Without this precaution, there would be too much wood, and little fruit.

The pepper exported from Malabar, which was formerly entirely in the hands of the Portugueſe, and was afterwards divided between the Dutch, Britiſh, and French, amounted to about 10,000,000 weight. Betel, or betle, is a ſpecies of this genus. See BETEL. It is a creeping and climbing plant like the ivy; and its leaves a good deal reſemble thoſe of the citron, though they are longer and narrower at the extremity. It grows in all parts of India, but thrives beſt in moiſt places. The natives cultivate it as we do the vine, placing props for it to run and climb upon; and it is a common practice to plant it againſt the tree which bears the areca-nut.

At all times of the day, and even in the night, the Indians chew the leaves of the betel, the bitterneſs of which is corrected by the areca that is wrapped up in them. There is conſtantly mixed with it the chinam, a

(A) See a copious account of the mode of cultivating pepper in Sumatra, in Mr Marſden's *Hiſtory of Sumatra*, or in the *New Annual Regiſter* for 1783, p. 147.

Piper || Piquet.

a kind of burnt lime made of ſhells. The rich frequently add perfumes, either to gratify their vanity or their ſenſuality.

It would be thought a breach of politeneſs among the Indians to take leave for any long time, without preſenting each other with a purſe of betel. It is a pledge of friendſhip that relieves the pain of abſence. No one dares to ſpeak to a ſuperior unleſs his mouth is perfumed with betel; it would even be rude to neglect this precaution with an equal. The women of gallantry are the moſt laviſh in the uſe of betel, as being a powerful incentive to love. Betel is taken after meals; it is chewed during a viſit; it is offered when you meet, and when you ſeparate; in ſhort, nothing is to be done without betel. If it is prejudicial to the teeth, it aſſiſts and ſtrengthens the ſtomach. At leaſt, it is a general faſhion that prevails throughout India.

London Medical Journal, vol. viii. part iii. p. 276. &c.

The *piper amalago*, or black pepper, and the *piper inequale*, or long pepper of Jamaica, with ſome other ſpecies, are indigenous, and known by the names of *joint wood*, or *peppery elders*. The firſt bears a ſmall ſpike, on which are attached a number of ſmall ſeeds of the ſize of muſtard. The whole of the plant has the exact taſte of the Eaſt India black pepper. The long pepper buſh grows taller than the amalago. The leaves are broad, ſmooth, and ſhining. The fruit is ſimilar to the long pepper of the ſhops, but ſmaller. The common people in Jamaica ſeaſon their meſſes with the black pepper. To preſerve both, the fruit may be ſlightly ſcalded when green, then dried, and wrapped in paper. Perhaps hereafter they may be deemed worthy of attention.

PIPRA, a genus of birds, of the order of *paſſeres*. See ORNITHOLOGY *Index*.

PIQUET, or PICKET, a celebrated game at cards, much in uſe throughout the polite world.

It is played between two perſons, with only 32 cards; all the duces, threes, fours, fives, and ſixes, being ſet aſide.

In reckoning at this game, every card goes for the number it bears, as a ten for ten; only all count cards go for ten, and the ace for eleven: and the uſual game is one hundred up. In playing, the ace wins the king, the king the queen, and ſo down.

Twelve cards are dealt round, uſually by two and two; which done, the remainder are laid in the middle: if one of the gameſters finds he has not a court card in his hand, he is to declare he has *carte-blanche*, and tell how many cards he will lay out, and deſire the other to diſcard, that he may ſhow his game, and ſatisfy his antagoniſt that the carte-blanche is real; for which he reckons ten.

Each perſon diſcards, i. e. lays aſide a certain number of his cards, and takes in a like number from the ſtock. The firſt of the eight cards may take three, four, or five; the dealer all the remainder, if he pleaſes.

After diſcarding, the eldeſt hand examines what ſuit he has moſt cards of; and reckoning how many points he has in that ſuit, if the other have not ſo many in that or any other ſuit, he tells one for every ten of that ſuit. He who thus reckons moſt is ſaid to win the point.

The point being over, each examines what *ſequences* he has of the ſame ſuit, viz. how many tierces, or ſequences of threes, quartes or fours, quintes or fives, ſixiemes, or ſixes, &c. For a tierce they reckon three points, for a quarte four, for a quinte 15, for a ſixieme 16, &c. And the ſeveral ſequences are diſtinguiſhed in dignity by the cards they begin from: thus ace king, and queen, are called *tierce major;* king, queen, and knave, *tierce to a king;* knave, ten, and nine, *tierce to a knave*, &c. and the beſt tierce, quarte, or quinte, i. e. that which takes its deſcent from the beſt card, prevails, ſo as to make all the others in that hand good, and deſtroy all thoſe in the other hand. In like manner, a quarte in one hand ſets aſide a tierce in the other.

The ſequences over, they proceed to examine how many aces, kings, queens, knaves, and tens, each holds; reckoning for every three of any ſort, three: but here too, as in ſequences, he that with the ſame number of threes has one that is higher than any the other has, e. gr. three aces, has all his others made good hereby, and his adverſary's all ſet aſide. But four of any ſort, which is called a *quatorze*, always ſets aſide three.

All the game in hand being thus reckoned, the eldeſt proceeds to play, reckoning one for every card he plays above a nine, and the other follows him in the ſuit; and the higheſt card of the ſuit wins the trick. Note, unleſs a trick be won with a card above a nine (except the laſt trick), nothing is reckoned for it, though the trick ſerves afterwards towards winning the cards; and that he who plays laſt does not reckon for his cards unleſs he wins the trick.

The cards being played out, he that has moſt tricks reckons ten for winning the cards. If they have tricks alike, neither reckons any thing. The deal being finiſhed, and each having marked up his game, they proceed to deal again as before, cutting afreſh each time for the deal.

If both parties be within a few points of being up, the carte-blanche is the firſt thing that reckons, then the point, then the ſequences, then the quatorzes or threes, then the tenth cards.

He that can reckon 30 in hand by carte-blanche, points, quintes, &c. without playing, before the other has reckoned any thing, reckons 90 for them; and this is called a *repique*. If he reckons above 30, he reckons ſo many above 90. If he can make up 30, part in hand and part play, ere the other has told any thing, he reckons for them 60. And this is called a *pique*. Whence the name of the game. He that wins all the tricks, inſtead of ten, which is his right for winning the cards, reckons 40. And this is called a *capot*.

Mr de Moivre, who has made this game the object of mathematical inveſtigation, has propoſed and ſolved the following problems: 1. To find at piquet the probability which the dealer has for taking one ace or more in three cards, he having none in his hand. He concludes from his computation, that it is 29 to 28 that the dealer takes one ace or more. 2. To find at piquet the probability which the eldeſt has of taking an ace or more in five cards, he having no ace in his hand. Anſwer: 232 to 91, or 5 to 2, nearly. 3. To find at piquet the probability which the eldeſt hand has of taking an ace and a king in five cards, he having none in his hand. Anſwer; the odds againſt the eldeſt hand taking

Piquet, Pira.

taking an ace and a king are 331 to 315, or 21 to 20 nearly. 4. To find at piquet the probability of having 12 cards dealt to, without king, queen, or knaves, which case is commonly called *cartes-blanches*. Anſwer; the odds againſt cartes-blanches are 1791 to 1 nearly. 5. To find how many different ſets, eſſentially different from one another, one may have at piquet before taking in. Anſwer; 28,967,278. This number falls ſhort of the ſum of all the diſtinct combinations, whereby 12 cards may be taken out of 32, this number being 225,792,840; but it muſt be conſidered that in that number ſeveral ſets of the ſame import, but differing in ſuit, might be taken, which would not introduce an eſſential difference among the ſets. The ſame author gives alſo ſome obſervations on this game, which he had from an experienced player. See *Doctrine of Chances*, p. 179, &c. M. de Monmort has treated of piquet in his *Analyſe des Jeux de Hazard*, p. 162.

PIRA, is a name by which a variety of foreign fiſhes are diſtinguiſhed. The *pira-aca* is a little horned fiſh of the Weſt Indies, called by Cluſius and others the *monoceros* or *unicorn-fiſh*. The *pira acangata* is the name of a Braſilian fiſh, which reſembles the perch both in ſize and ſhape. It ſeldom exceeds four or five inches in length; its mouth is ſmall; its tail forked. On the back it has only one long fin, which is ſupported by rigid and prickly ſpines. This fin it can depreſs at pleaſure, and ſink within a cavity made for it in the back. Its ſcales are of a ſilvery white colour; it is wholeſome and well taſted. *Pira bebe* is the name of the milvus, or kite-fiſh. *Pira-coaba* is an American fiſh of the truttaceous kind, of a very delicate flavour. It grows to the length of 12 inches; its noſe is pointed, and its mouth large, but without teeth; the upper jaw is longer than the under one, and hangs over like a cartilaginous prominence; its eyes are very large, and its tail is forked; under each of the gill fins there is a beard made of ſix white filaments, and covered with ſilvery ſcales. *Pira jurumenbeca* is a Braſilian fiſh, otherwiſe called *bocca molle*. It lives in the muddy bottom of the American ſeas, and is a long-bodied not flatted fiſh. It grows to a great ſize, being found nine, and ſometimes even ten or eleven, feet long, and two feet and a half thick. It has one long fin on the back, the anterior part of which is thin and pellucid. There is alſo a cavity on the back, as in the pira acangata, into which the fin can be depreſſed at pleaſure; the tail is not forked, and the ſcales are all of a ſilvery colour and brightneſs. The fiſh is very well taſted; the *pira pixanga* is another Braſilian fiſh of the turdus or wraſſe kind, and called by ſome the *gutviſch*. It is generally about four or five inches long; its mouth is pretty large, and furniſhed with very ſmall and very ſharp teeth; its head is ſmall, but its eyes are large and prominent, the pupil being of a fine turquoiſe colour, and the iris yellow and red in a variety of ſhades. The coverings of the gills end in a triangular figure, and are terminated by a ſhort ſpine or prickle; its ſcales are very ſmall, and ſo evenly arranged, and cloſely laid on the fleſh, that it is very ſmooth to the touch; its tail is rounded at the end; its whole body, head, tail, and fins, are of a pale yellow colour, variegated all over with very beautiful blood-coloured ſpots; theſe are round, and of the bigneſs of hemp-ſeed on the back and ſides, and ſomething larger on the belly; the fins are all ſpotted in the ſame manner, and are all marked with an edge of red. It is caught among the rocks, and about the ſhores, and is a very well taſted fiſh. *Piranha* is an American fiſh, more generally known by the name *piraya*. *Piraquiba*, or *ipiraquiba*, is the name of a fiſh originally Braſilian, which ſome writers apply to the *remora* or *ſucking fiſh*.

Pira, Piræus.

PIRÆUS PORTUS, in *Ancient Geography*, a celebrated port to the weſt of Athens, conſiſting naturally of three harbours or baſons, (Thucydides); which lay neglected, till Themiſtocles put the Athenians on making it a commodious port, (Nepos); the Phalerus, a ſmall port, and not far from the city, being what they uſed before that time, (Pauſanias, Nepos). Piræus was originally a village of Attica, (Pauſanias); an iſland, (Strabo); and though diſtant 40 ſtadia from Athens, was joined to it by two long walls, (Thucydides), and itſelf locked or walled round, (Nepos): A very commodious and ſafe harbour. The whole of its compaſs was 60 ſtadia, including the Munichia. Not far from the Piræus ſtood the ſepulchre of Themiſtocles; whither his friends conveyed his bones from Magneſia, into the Hither Aſia, (Cicero, Plutarch, Pauſanias). The entrance of the Piræus is narrow, and formed by two rocky points, one belonging to the promontory of Eetion, the other to that of Alcimus. Within were three ſtations for ſhipping; Kantharus, ſo named from a hero; Aphrodiſium, from a temple of Venus; and Zea, the reſort of veſſels laden with grain. By it was a demos or borough town of the ſame name before the time of Themiſtocles, who recommended the exchanging its triple harbour for the ſingle one of Phalerum, both as more capacious and as better ſituated for navigators. The wall was begun by him when archon, in the ſecond year of the 75th Olympiad, 477 years before Chriſt; and afterwards he urged the Athenians to complete it as the importance of the place deſerved. This whole fortification was of hewn ſtone, without cement or other material, except lead and iron, which were uſed to hold together the exterior ranges or facings. It was ſo wide that loaded carts could paſs on it in different directions, and it was 40 cubits high, which was about half what he had deſigned.

Chandler's Travels in Greece, p. 19. &c.

The Piræus, as Athens flouriſhed, became the common emporium of all Greece. Hippodamus an architect, celebrated, beſides other monuments of his genius, as the inventor of many improvements in houſe-building, was employed to lay out the ground. Five porticoes, which uniting formed the *Long Portico*, were erected by the ports. Here was an *agora* or market-place, and, farther from the ſea, another called *Hippodamia*. By the veſſels were dwellings for the mariners. A theatre was opened, temples were raiſed, and the Piræus, which ſurpaſſed the city in utility, began to equal it in dignity. The cavities and windings of Munichia, natural and artificial, were filled with houſes; and the whole ſettlement, comprehending Phalerum and the ports of the Piræus, with the arſenals, the ſtorehouſes, the famous armoury of which Philo was the architect, and the ſheds for 300, and afterwards 400, triremes, reſembled the city of Rhodes, which had been planned by the ſame Hippodamus. The ports, on the commencement of the Peloponneſian

Piræus, Piracy.

Peloponnesian war, were secured with chains. Centinels were stationed, and the Piræus was carefully guarded.

The Piræus was reduced with great difficulty by Sylla, who demolished the walls, and set fire to the armoury and arsenals. In the civil war it was in a defenceless condition. Calenus, lieutenant to Cæsar, seized it, invested Athens, and ravaged the territory. Strabo, who lived under the emperors Augustus and Tiberius, observes, that the many wars had destroyed the long walls, with the fortress of Munychia, and had contracted the Piræus into a small settlement by the ports and the temple of Jupiter Saviour. This fabric was then adorned with wonderful pictures, the works of illustrious artists, and on the outside with statues. In the second century, besides houses for triremes, the temple of Jupiter and Minerva remained, with their images in brass, and a temple of Venus, a portico, and the tomb of Themistocles.

The port of the Piræus has been named *Porto Lione*, from the marble lion seen in the chart, and also *Porto Dracco*. The lion has been described as a piece of admirable sculpture, 10 feet high, and as reposing on its hinder parts. It was pierced, and, as some have conjectured, had belonged to a fountain. Near Athens, in the way to Eleusis, was another, the posture couchant; probably its companion. Both these were removed to Venice by the famous general Morosini, and are to be seen there before the arsenal. At the mouth of the port are two ruined piers. A few vessels, mostly small craft, frequent it. Some low land at the head seems an incroachment on the water. The buildings are a mean customhouse, with a few sheds; and by the shore on the east side, a warehouse belonging to the French; and a Greek monastery dedicated to St Spiridion. On the opposite side is a rocky ridge, on which are remnants of the ancient wall, and of a gateway towards Athens. By the water-edge are vestiges of building; and going from the customhouse to the city on the right hand, traces of a small theatre in the side of the hill of Munychia.

PIRACY, the crime of robbery and depredation upon the high seas.

By the ancient common law, piracy, if committed by a subject, was held to be a species of treason, being contrary to his natural allegiance; and by an alien, to be felony only: but now, since the statute of treasons, 25 Edw. III. c. 2. it is held to be only felony in a subject. Formerly it was only cognizable by the admiralty courts, which proceed by the rules of the civil law. But, it being inconsistent with the liberties of the nation, that any man's life should be taken away, unless by the judgement of his peers, or the common law of the land, the statute 28 Hen. VIII. c. 15. established a new jurisdiction for this purpose; which proceeds according to the course of the common law.

The offence of piracy, by common law, consists in committing those acts of robbery and depredation upon the high seas, which, if committed upon land, would have amounted to felony there. But, by statute, some other offences are made piracy also: as, by statute 11 and 12 W. III. c. 7. if any natural-born subject commits any act of hostility upon the high seas, against others of his majesty's subjects, under colour of a commission from any foreign power; this, though it would only be an act of war in an alien, shall be construed piracy in a subject. And farther, any commander, or other seafaring person, betraying his trust, and running away with any ship, boat, ordnance, ammunition, or goods; or yielding them up voluntarily to a pirate; or conspiring to do these acts; or any person assaulting the commander of a vessel, to hinder him from fighting in defence of his ship; or confining him, or causing or endeavouring to cause a revolt on board; shall, for each of these offences, be adjudged a pirate, felon, and robber, and shall suffer death, whether he be principal, or merely accessory by setting forth such pirates, or abetting them before the fact, or receiving or concealing them or their goods after it. And the statute 4 Geo. I. c. 11. expressly excludes the principals from the benefit of clergy. By the statute 8 Geo. I. c. 24. the trading with known pirates, or furnishing them with ammunition, or fitting out any vessel for that purpose, or in anywise consulting, combining, confederating, or corresponding with them; or the forcibly boarding any merchant vessel, though without seizing or carrying her off, and destroying or throwing any of the goods overboard; shall be deemed piracy: and such accessories to piracy as are described by the statute of King William are declared to be principal pirates; and all pirates convicted by virtue of this act are made felons without benefit of clergy. By the same statutes also, (to encourage the defence of merchant-vessels against pirates), the commanders or seamen wounded, and the widows of such seamen as are slain, in any piratical engagement, shall be entitled to a bounty to be divided among them, not exceeding one-fiftieth part of the value of the cargo on board: and such wounded seamen shall be intitled to the pension of Greenwich hospital; which no other seamen are, except only such as have served in a ship of war. And if the commander shall behave cowardly, by not defending the ship, if she carry guns or arms; or shall discharge the mariners from fighting, so that the ship falls into the hands of pirates; such commander shall forfeit all his wages, and suffer six months imprisonment. Lastly, by statute 18 Geo. II. c. 30. any natural-born subject or denizen, who in time of war shall commit hostilities at sea against any of his fellow-subjects, or shall assist an enemy on that element, is liable to be tried and convicted as a pirate.

Piracy, Pirate.

PIRATE, (πειρατης, Gr.); a sea-robber, or an armed ship that roams the seas without any legal commission, and seizes or plunders every vessel she meets indiscriminately, whether friends or enemies.

The colours usually displayed by pirates are said to be a black field, with a death's head, a battle-axe, and hour-glass. The last instrument is generally supposed to determine the time allowed to the prisoners, whom they take, to consider whether they will join the pirates in their felonious combination, or be put to death, which is often perpetrated in the most cruel manner.

Among the most celebrated pirates of the north is recorded Alvilda, daughter of a king of the Goths named *Syparaus*. She embraced this occupation to deliver herself from the violence imposed on her inclination, by a marriage with Alf, son of Sigarus king of Denmark. She dressed herself as a man; and composed her band of rowers, and the rest of her crew, of a number of young women attired in the same manner. Amongst the first of her cruizes, she touched at a place where a company

Pirate || Piron.

of pirates bewailed the death of their captain. The ſtrangers were captivated with the agreeable manners of Alvilda, and choſe her for their chief. By this reinforcement ſhe became ſo formidable upon the ſea, that Prince Alf came to engage her. She ſuſtained his attacks for a conſiderable time: but, in a vigorous action, Alf boarded her veſſel, and having killed the greateſt part of her crew, ſeized the captain, namely herſelf; whom nevertheleſs he knew not, becauſe the princeſs had a caſque which covered her viſage. Being maſter of her perſon, he removed the caſque; and in ſpite of her diſguiſe, inſtantly recognized her, and offered her his hand in wedlock.

PIRENE, (Pliny); a fountain ſacred to the muſes, ſpringing below the top of the Acrocorinthus, a high and ſteep mountain which hangs over Corinth. Its waters were agreeable to drink, (Pauſanias); extremely clear, (Strabo); very light, (Athenæus); and pale, (Perſius): having relation either to the grief of Pirene, mother of Cenchrea, from whoſe tears this fountain aroſe, (Pauſanias); or to the paleneſs brought on by the too eager purſuits of the muſes.

PIROMALLI, Paul, a dominican of Calabria, was ſent a miſſionary into the eaſt. He remained a long time in Armenia, where he had the happineſs to bring back to the church many ſchiſmatics and Eutycheans, and the patriarch himſelf, who had before thrown every obſtacle in his way. He afterwards paſſed into Georgia and Perſia, then into Poland, in quality of Pope Urban VIII.'s nuncio, in order to appeaſe the diſturbances which had been occaſioned there by the diſputes of the Armenians, who were very numerous in that country. Piromalli reunited them in the profeſſion of the ſame faith, and obſervance of the ſame ceremonies. In his return to Italy, he was taken by ſome corſairs who carried him priſoner to Tunis. As ſoon as he was ranſomed, he went to Rome, and gave an account of his miſſion to the pope, who conferred upon him ſome ſignal marks of his eſteem. His holineſs entruſted him with the reviſal of an Armenian Bible, and ſent him again into the eaſt, where he was promoted, in 1655, to the biſhopric of Naſſivan. After having governed that church for nine years, he returned to Italy, and took the charge of the church of Baſignano, where he died three years after in 1667. His charity, his zeal, and other virtues, did honour to the Epiſcopal office. There are extant of his writings, 1. Some works of Controverſy and Theology. 2. Two Dictionaries; the one a Latin-Perſian, and the other an Armenian-Latin. 3. An Armenian Grammar. 4. A Directory, which is of great uſe in correcting Armenian books. All theſe works equally diſtinguiſh him for virtue and for learning.

PIRON, Alexis, a French poet, was born at Dijon in July 1689, where his father was an apothecary, and where he paſſed more than 30 years in idle and deſtructive diſſipation. He was at length obliged to quit the place of his nativity, in order to avoid the reproaches of his fellow citizens, on account of an ode which he had written, and which gave great offence. His relations not being able to give him much aſſiſtance, he ſupported himſelf at Paris by means of his pen, the ſtrokes of which were as beautiful and fair as thoſe of an engraver. He lived in the houſe of M. de Belliſle as his ſecretary, and afterwards with a financier, who did not know that he had a man of genius under his roof. His reputation as a writer commenced with ſome pieces which he publiſhed for the entertainment of the populace, and which ſhowed ſtrong marks of original invention; but what fully eſtabliſhed his character in this way was his comedy intitled *Metromany*, which was the beſt that had appeared in France ſince Regnard's Gameſter. This performance, in five acts, well conducted, replete with genius, wit, and humour, was acted with the greateſt ſucceſs upon the French ſtage in 1738. The author met with every attention in the capital which was due to a man of real genius, and whoſe flaſhes of wit were inexhauſtible. We ſhall inſert a few anecdotes of him, which will ſerve to ſhow his character and turn of mind. In Burgundy the inhabitants of Beaune are called the *Aſſes of Beaune*. Piron often indulged his ſatirical diſpoſition at their expence. One day as he was taking a walk in the neighbourhood of that city, he diverted himſelf with cutting down all the thiſtles which he met with. When a friend aſked him his reaſon for doing ſo, he replied, *J'ai à me plaindre des Beaunois; je leur coupe les vivres*, i. e. "I am ſorry indeed for the Beaunians; for I am cutting down their food." Being told again that theſe people would certainly be revenged of him,

> *Allez*, (ſays he) *Allez: je ne crains point leur impuiſſant couroux;*
> *Et quand je ſerois ſeul, je les batterois tous.*

"Get you gone, get you gone: I fear not their feeble revenge; for though alone, I ſhould beat them all." Going into a theatre one time where a play was acting, he aſked what it was? The Cheats of Scapin, gravely replied a young Beaunian. "Ah! Sir, (ſays Piron, after thanking him), I took it to be the Cheats of Oreſtes." In the time of the play, ſome body addreſſes the company with "Silence there, gentlemen, we don't hear." "It is not at leaſt (cried Piron) for want of ears." A biſhop one day aſked Piron, during the diſputes about Janſeniſm, "Did you read my mandate, Mr Piron?" No, my lord; and you——The converſation turning very warm, the biſhop reminded him of the diſtance which birth and rank had put between them. "Sir (ſays Piron), I have plainly the ſuperiority over you at this moment; for I am in the right, and you are in the wrong."—Voltaire's Semiramis did not meet with a very favourable reception the firſt time it was acted. The author finding Piron behind the ſcenes, aſked him what he thought of his performance? "I think (replied he) you would have been pleaſed that I had been the author of it." The performer of the character Ferdinand Cortez (the title of one of Piron's tragedies) having requeſted ſome corrections to be made on the play the firſt time it was acted. Piron fired at the word *corrections*. The player, who was deputed to wait upon the author with this requeſt, cited the example of Voltaire, who corrected ſome of his pieces in order to gratify the taſte of the public. "The caſes are widely different (replied Piron); Voltaire works in chequer-work, and I caſt in braſs" If this anſwer be not very modeſt, we muſt allow that it does not want wit. He thought himſelf, if not ſuperior, at leaſt equal to Voltaire. Some perſon congratulating him on having compoſed the beſt comedy of this age, he anſwered, with more frankneſs than modeſty, "Add too, and the beſt tragedy."

Piron, Pisa.

gedy." The following verses are well known, in which he says:

En deux mots voulez-vous distinguer et connoitre
Le rimeur Dijonnois et le Parisien?
Le premier ne fut rien, et ne voulut rien etre;
L'autre voulut tout etre, et ne fut presque rien.

We see by these different traits that Piron had a sufficient stock of self-conceit. What helped to increase it, and make him fancy himself superior to the most celebrated of his contemporaries, was, that his company, on account of his original humour, of which he had an uncommon share, was more courted than that of Voltaire, who was otherwise too lively, too captious, and crabbed. But those who have favoured us with an account of his many witticisms in conversation, would have done more honour to his memory if they had passed over such as were either indecent or insipid. A thing often pleases over a glass of wine, which will not give the same satisfaction when it is repeated, especially if, in repeating it, you want to make it appear of some importance. Be that as it may, Piron's mischievous ingenuity was partly the cause which excluded him from the French Academy.—"I could not (said he) make thirty-nine people think as I do, and I could less think as thirty-nine do." He called that celebrated society very unjustly *les invalides du bel esprit*, "the invalids of wit;" and yet he often endeavoured to be one of those invalids. His death was hastened by a fall which he got a little before. He died the 21st of January 1773, at the age of 83. He had prepared for himself the following epitaph, in the way of an epigram:

Ci gît Piron, qui ne fut rien,
Pas même académicien.

"Here lies Piron, who was nothing, not even an academician."

His wife Maria Theresa Quenandon, who died in 1751, he describes as a sweet and most agreeable companion. They lived together for several years; and no husband ever discharged his duty with more fidelity and attention.

A collection of his works appeared in 1776, in 7 vols 8vo, and 9 vols 12mo. The principal pieces are, The School of Fathers; a comedy acted in 1728 under the title of Ungrateful Sons. Callisthenes; a tragedy, the subject of which is taken from Justin. The Mysterious Lover, a comedy. Gustavus and Ferdinand Cortez, two tragedies; some scenes of which discover an original genius, but the versification neither pleases the ear nor affects the heart. Metromany, a comedy. The Courses of Tempe, an ingenious pastoral, in which the manners both of the town and country are pleasantly drawn. Some odes, poems, fables, and epigrams. In this last kind of poetry he was very successful, and he may be placed after Marot and Rousseau. There was no occasion for loading the public with 7 vols of his works; the half of that number might have sufficed. For, excepting Metromany, Gustavus, the Courses of Tempe, some odes, about 20 epigrams, three or four fables, and some epistles, the rest are but indifferent, and have no claim to any extraordinary merit.

PISA, a large town of Tuscany in Italy, situated on the river Arno, 52 miles from Florence. It was a famous republic, till subdued, first by the duke of Milan, and then by the Florentines in the year 1406. Before it lost its freedom, it is said to have contained near 150,000 inhabitants, but now it has not above 16,000 or 17,000. It was founded, we are told, by the Pisans of Peloponnesus, and afterwards became one of the 12 municipia of Tuscany. Its neighbourhood to Leghorn, which is now the chief port in the Mediterranean, though formerly of little or no note for trade, has contributed greatly to the decay of Pisa, which, however, begins to lift up its head again, under the auspices of the present grand duke, who has made it his winter residence. Between Pisa and Leghorn is a canal 16 Italian miles in length.—Its territory is very fruitful; abounding in corn, wine, and fruit, and fine cattle. The houses are well built, and the streets even, broad, and well paved; but in many places overrun with grass. The university is well endowed, and has able professors, but is not in a very flourishing condition. The exchange is a stately structure, but little frequented. The grand duke's galleys are built, and commonly stationed here. This city is also the principal residence of the order of St Stephen, and the see of an archbishop. The cathedral, a large Gothic pile, contains a great number of excellent paintings and other curiosities. This church is dedicated to St Mary; is very advantageously situated in the middle of a large piazza, and built out of a great heap of wrought marble, such as pillars, pedestals, capitals, cornices, and architraves, part of the spoils which the Pisans took in their eastern expeditions, when the republic was in a flourishing condition. The roof is supported by 76 high marble pillars of different colours, and finely gilt. Both the church and the cupola are covered with lead. The choir is painted by good hands, and the floor is mosaic work. The brazen doors are curiously wrought with the history of the Old and New Testament, by Bonanno, an ancient statuary. The chapel of St Rainerius is richly adorned with gilt metals, columns of porphyry, and fine paintings. In the middle of the nave of the church you see two brazen tombs, raised upon pillars. The marble pulpit was carved by John Pisano, and the choir by Julian da Majana. Joining thereto is the altar, over which is preserved a hollow globe or vessel of marble, wherein they kept the sacrament for the new baptized, according to the opinion of Father Mabillon. In the square before the church, you see a pillar upon which is the measure of the ancient Roman talent. In the same square with the dome, stands the baptistery, a round fabric supported by stately pillars, and remarkable for a very extraordinary echo.

Pisa.

On the north side of the cathedral is the burying-place, called *Campo Santo*, being covered with earth brought from the Holy Land. This burying-place is inclosed with a broad portico, well painted, and paved with grave stones. Here are a great many ancient tombs, among the rest that of Beatrix, mother of the countess Mathilda, with marble basso-relievos, which the Pisans brought from Greece, where you see the hunt of Meleager, which assisted Nicholas of Pisa in the restoration of sculpture. The walls of the Campo Santo are painted by the best masters of their times. Giotto has drawn six historical pieces of Job; and Andrea Orgagna has given a fine piece of the last judgement. Under the portico there is a decree of the city, ordering the inhabitants to wear mourning a year for the death of Cæsar.

Near

Near the church you see a steeple in the form of a cylinder, to which you ascend by 153 steps; it inclines 15 feet on one side, which some ascribe to art, but others to the sinking of the foundation. Its inclination is so great that a plumb-line let fall from the top touches the ground at the distance of almost 15 feet from the bottom. It was built by John of Inspruck and Bonanno of Pisa, in 1174. Near this steeple is a fine hospital, dependent on that of St Maria Nuova in Florence.

The steeple of the church of the Augustinians is also very fine, being an octagon, adorned with pillars, and built by Nicholas of Pisa. In the great market-place there is a statue of Plenty, by Pierino da Vinci. In the church of St Matthew, the painting of the ceiling by the brothers Melani, natives of this city, is an admired performance. The church of the knights of St Stephen, decorated with the trophies taken from the Saracens, is all of marble, with marble steps, and a front adorned with marble statues. In the square there is a statue of Cosmo I. upon a very fine pedestal. Contiguous to the church is the convent or palace of the knights, which is worth seeing, as also the churches Della Madonna and Della Spina; the last of which was built by a beggar, whose figure you may see on the outside of the wall. It is pretended that one of the thorns of the crown which was placed on our Saviour's head is preserved here. Belonging to the university there is a great number of colleges, the chief of which is the Sapienza, where the professors read their public lectures; next to which are the colleges Puteano, Ferdinando, Ricci, and others. Besides the public palace, and that of the grand duke, there are several others with marble fronts, the finest of which is that of Lanfranchi, which, with the rest along the banks of the Arno, makes a very fine appearance. There is here a good dock, where they build the galleys, which are conveyed by the Arno to Leghorn. They have a famous aqueduct in this town, consisting of 5000 arches, which conveys the water from the hills at five miles distance. This water is esteemed the best in Italy, and is carried in flasks to Florence and Leghorn. The neighbouring country produces great store of corn and wine, but the latter is not much esteemed. They have very good butter in this neighbourhood, which is a scarce commodity in Italy. The city for its defence has a moat, walls, a castle, fort, and citadel; the last of which is a modern work. The Arno is of a considerable breadth here, and has three bridges over it, one of them of marble: two leagues below the town it falls into the sea. The physic-garden is very spacious, contains a great number of plants, and is decorated with water-works: over the door leading into it are these words, *Hic Argus sed non Briareus esto:* i. e. "Employ the eyes of Argus, but not the hands of Briareus. The air is said to be unwholesome here in summer, on account of the neighbouring morasses. Many buffaloes are bred in the neighbouring country, and their flesh is commonly eaten. Between Pisa and Lucca are hot baths. E. Long. 10. 17. N. Lat. 43. 43.

PISCARY, in our ancient statutes, the liberty of fishing in another man's waters.

PISCES, in *Astronomy*, the 12th sign or constellation of the zodiac.

PISCIDIA, a genus of plants belonging to the diadelphia class. See BOTANY *Index*.

PISCIDIA Erythrina, or *Dogwood-tree*, is employed to intoxicate fish. For this purpose, the bark is pounded small, put into bags, and soaked in salt water. The juice, which is of a red colour, makes the fish stupid, so that they are easily taken.

PISCINA, in antiquity, a large bason in a public place or square, where the Roman youth learned to swim: and which was surrounded with a high wall, to prevent filth from being thrown into it.—This word is also used for a lavatory among the Turks, placed in the middle court of a mosque or temple, where the Mussulmans wash themselves before they offer their prayers.

PISISTRATUS, an Athenian who early distinguished himself by his valour in the field, and by his address and eloquence at home. After he had rendered himself the favourite of the populace by his liberality and by the intrepidity with which he had fought their battles, particularly near Salamis, he resolved to make himself master of his country. Every thing seemed favourable to his ambitious views; but Solon alone, who was then at the head of affairs, and who had lately enforced his celebrated laws, opposed him, and discovered his duplicity and artful behaviour before the public assembly. Pisistratus was not disheartened by the measures of his relation Solon, but he had recourse to artifice. In returning from his country-house, he cut himself in various places; and after he had exposed his mangled body to the eyes of the populace, deplored his misfortunes, and accused his enemies of attempts upon his life, because he was the friend of the people, the guardian of the poor, and the reliever of the oppressed, he claimed a chosen body of 50 men from the populace to defend his person in future from the malevolence and the cruelty of his enemies. The unsuspecting people unanimously granted his request, though Solon opposed it with all his influence; and Pisistratus had no sooner received an armed band on whose fidelity and attachment he could rely, than he seized the citadel of Athens, and made himself absolute. The people too late perceived their credulity; yet, though the tyrant was popular, two of the citizens, Megacles and Lycurgus, conspired together against him, and by their means he was forcibly ejected from the city. His house and all his effects were exposed to sale; but there was found in Athens only one man who would buy them. The private dissensions of the friends of liberty proved favourable to the expelled tyrant; and Megacles, who was jealous of Lycurgus, secretly promised to restore Pisistratus to all his rights and privileges in Athens, if he would marry his daughter. Pisistratus consented; and by the assistance of his father-in-law, he was soon enabled to expel Lycurgus, and to re-establish himself. By means of a woman called *Phya*, whose shape was tall, whose features were noble and commanding, he imposed upon the people, and created himself adherents even among his enemies. Phya was conducted through the streets of the city, and showing herself subservient to the artifice of Pisistratus, she was announced as Minerva, the goddess of wisdom, and the patroness of Athens, who was come down from Heaven to re-establish her favourite Pisistratus in a power which was sanctioned by the will of Heaven, and favoured by the affection of the people. In the midst of his triumph, however, Pisistratus found himself unsupported; and some time after, when

Bibliotheca Classica, by Lempriere.

when he repudiated the daughter of Megacles, he found that not only the citizens, but even his very troops, were alienated from him by the influence, the intrigues, and the bribery of his father-in-law. He fled from Athens where he no longer could maintain his power, and retired to Eubœa. Eleven years after he was drawn from his obscure retreat, by means of his son Hippias, and he was a third time received by the people of Athens as their master and sovereign. Upon this he sacrificed to his resentment the friends of Megacles, but he did not lose sight of the public good, and while he sought the aggrandizement of his family, he did not neglect the dignity and the honour of the Athenian name. He died about 528 years before the Christian era, after he had enjoyed the sovereign power at Athens for 33 years, and he was succeeded by his son Hipparchus. Pisistratus claims our admiration for his justice, his liberality, and his moderation. If he was dreaded and detested as a tyrant, the Athenians loved and respected his private virtues and his patriotism as a fellow-citizen: and the opprobrium which generally falls on his head may be attributed not to the severity of his administration, but to the republican principles of the Athenians, who hated and exclaimed against the moderation and equity of the mildest sovereign, while they flattered the pride and gratified the guilty desires of the most tyrannical of their fellow subjects. Pisistratus often refused to punish the insolence of his enemies; and when he had one day been virulently accused of murder, rather than inflict immediate punishment upon the man who had criminated him, he went to the areopagus, and there convinced the Athenians that the accusations of his enemies were groundless, and that his life was irreproachable. It is to his labours that we are indebted for the preservation of the poems of Homer; and he was the first, according to Cicero, who introduced them at Athens in the order in which they now stand. He also established a public library at Athens; and the valuable books which he had diligently collected were carried into Persia when Xerxes made himself master of the capital of Attica. Hipparchus and Hippias the sons of Pisistratus, who had received the name of *Pisistratidæ*, rendered themselves as illustrious as their father; but the flames of liberty were too powerful to be extinguished. The Pisistratidæ governed with great moderation, but the name of tyrant or sovereign was insupportable to the Athenians. Two of the most respectable of the citizens, called *Harmodius* and *Aristogiton*, conspired against them, and Hipparchus was dispatched in a public assembly. This murder was not, however, attended with any advantages; and though the two leaders of the conspiracy, who have been celebrated through every age for their patriotism, were supported by the people, yet Hippias quelled the tumult by his uncommon firmness and prudence, and for a while preserved that peace in Athens which his father had often been unable to command. This was not long to continue. Hippias was at last expelled by the united efforts of the Athenians and of their allies, and he left Attica, when he found himself unable to maintain his power and independence. The rest of the family of Pisistratus followed him in his banishment; and after they had refused to accept the liberal offers of the princes of Thessaly, and the king of Macedonia, who wished them to settle in their respective territories, the Pisistratidæ retired to Sigæum, which their father had in the summit of his power conquered and bequeathed to his posterity. After the banishment of the Pisistratidæ, the Athenians became more than commonly jealous of their liberty, and often sacrificed the most powerful of their citizens, apprehensive of the influence which popularity and a well-directed liberality might gain among a fickle and unsettled populace. The Pisistratidæ were banished from Athens about 18 years after the death of Pisistratus.

PISMIRES, or Ants, are a kind of insects very common in Africa; of which there is so great a variety, and such innumerable swarms, that they destroy not only the fruits of the ground but sometimes even men and beasts in so little time as one single night; and would, without all doubt, prove more fatally destructive to the inhabitants, were they not so happily destroyed by a proportionable number of monkeys and other animals, who greedily devour them. The far greater part of the vast continent of Africa is afflicted with these and some other grievous plagues, and particularly with the horrid visitation of locusts, which seldom fail a year of laying waste some of the provinces.

PISO, Lucius Calpurnius, surnamed *Frugi* on account of his frugality, was descended of the illustrious family of the Pisos, which gave so many great men to the Roman republic. He was tribune of the people in the year 149 before Christ, and afterwards consul. During his tribuneship, he published a law against the crime of concussion or extortion, intitled *Lex Calpurnia de pecuniis repetundis*. He happily ended the war in Sicily. To reward the services of one of his sons, who had distinguished himself in that expedition, he left him by his will a golden crown, weighing 20 pounds. Piso joined to the qualities of a good citizen the talents of a lawyer, an orator, and historian.

Piso, *Caius Calpurnius*, a Roman consul in the year 67 before Christ, was author of the law which forbade canvassing for public offices, intitled *Lex Calpurnia de ambitu*. He displayed all the firmness worthy of a consul in one of the most stormy periods of the republic. The Roman people, deceived by the flattery of Marcus Palicanus, a turbulent and seditious fellow, were on the eve of loading themselves with the greatest disgrace, by putting the supreme authority into the hands of this man, who deserved punishment rather than honours. The tribunes of the people, by their harangues, inflamed the blind fury of the multitude, already sufficiently mutinous of themselves. In this situation, Piso mounted the rostrum, and being asked if he would declare Palicanus consul, in case the suffrages of the people should concur in the nomination, he instantly replied, that "he did not think the republic was yet involved in such darkness and despair as to be capable of committing so infamous an action." Being afterwards strongly and repeatedly called upon to say, "what he would do, if the thing should happen?" his answer was, "No, I would not name him." By this firm and laconic answer he deprived Palicanus of the dignity to which he aspired. Piso, according to Cicero, was not possessed of a quick conception, but he thought maturely, and with judgment, and, by a proper firmness, he appeared to be an abler man than he really was.

Piso, Pissasphaltum.

Piso, *Cneius Calpurnius*, was consul in the reign of Augustus, and governor of Syria under Tiberius, whose confidant he was. It is said, that by the order of this emperor he caused Germanicus to be poisoned. Being accused of that crime, and seeing himself abandoned by every body, he laid violent hands on himself in the 20th year of our Lord. He was a man of insupportable pride and excessive violence. Some instances of his wicked cruelty have been handed down to us. Having given orders in the heat of his passion to conduct to punishment a soldier, as guilty of the death of one of his companions, because he had gone out of the camp with him and returned without him, no prayers or intreaty could prevail with Piso to suspend the execution of this sentence until the affair should be properly investigated. The soldier was led without the entrenchments, and had already presented his head to receive the fatal stroke, when his companion whom he was accused of having killed made his appearance again. Whereupon the centurion, whose office it was to see the sentence executed, ordered the executioner to put up his sword into the scabbard. Those two companions, after embracing each other, are conducted to Piso, amidst the acclamations of the whole army, and a prodigious crowd of people. Piso, foaming with rage, ascends his tribune, and pronounces the same sentence of death against the whole three, without excepting the centurion who had brought back the condemned soldier, in these terms: "You I order to be put to death because you have been already condemned: you, because you have been the cause of the condemnation of your comrade; and you, because having got orders to put that soldier to death, you have not obeyed your prince."

PISSASPHALTUM, or Asphaltum, Earth-pitch; a fluid, opaque, mineral body, of a thick consistence, strong smell, readily inflammable, but leaving a residuum of greyish ashes after burning. It arises out of the cracks of the rocks, in several places in the island of Sumatra, and some other places in the East Indies, where it is much esteemed in paralytic disorders. There is a remarkable mine of it in the island of Bua, (see Bua), of which the following curious description is given us by the Abbe Fortis. "The island is divided into two promontories between the north and west. Crossing over the top of the latter, which is not half a mile broad, and descending in a right line towards the sea, one is conducted to a hole well known to the inhabitants. This hole extends not much above 12 feet, and from its bottom above 25 feet perpendicular, arise the marble strata which sustain the irregular masses that surround the top of the mountain.

Pissasphaltum || Pistacia.

This pissasphaltum is of the most perfect quality, black and shining, very pure, odorous, and cohesive; and it comes out almost liquid, but hardens in large drops when the sun sets. On breaking many of these drops on the spot, I found that almost every one of them had an inner cavity full of very clear water.

"The greatest breadth of the tears that I saw was two inches, and the common breadth is half an inch. The chinks and fissures of the marble, from whence this bituminous pitch transudes, are not more than the thickness of a thread; and for the most part are so imperceptible, that were it not for the pitch itself, whereby they are blackened, they could not by any means be distinguished by the naked eye. To the narrowness of these passages is, no doubt, in part owing the small quantity of pissasphaltum that transpires."

After some conjectures about the origin of this mine, our author proceeds to inform us that the pissasphaltum of Bua is correspondent to that fossil production which by Hasselquist, in his Travels, is called *mumia minerale*, and *mumia nativa Persiana* by Kempfer, which the Egyptians made use of to embalm their kings (A). It is found in a cave of Mount Caucasus, which is kept shut, and carefully guarded by order of the king of Persia. One of the qualities assigned by M. Linnæus to the finest bitumen is to smoke when laid on the fire, as ours does, emitting a smell of pitch not disagreeable. He believes it would be very good for wounds, as the oriental mumia is, and like the pitch of Castro, which is frequently used by the Roman chirurgeons for fractures, contusions, and in many external applications. See Asphaltum, Mineralogy *Index*.

PISSELÆUM indicum, *Barbadoes Tar;* a mineral fluid of the nature of the thicker bitumens, and of all others the most approaching, in appearance, colour, and consistence, to the true pissasphaltum, but differing from it in other respects. It is very frequent in many parts of America, where it is found trickling down the sides of mountains in large quantities, and sometimes floating on the surface of the waters. It has been greatly recommended internally in coughs and other disorders of the breast and lungs.

PISTACIA, Turpentine-tree, *Pistachia nut* and *Mastick-tree;* a genus of plants belonging to the dioecia class. The most remarkable species are, 1. The terebinthus, or pistachia-tree, which grows naturally in Arabia, Persia, and Syria, whence the nuts are annually brought to Europe. In those countries it grows to the height

(A) "Mumiahi, or native Persian mummy. It proceeds from a hard rock in very small quantity. It is a bituminous juice, that transudes from the stony superficies of the hill, resembling in appearance coarse shoemakers wax, as well in its colour as in its density and ductility. While adherent to the rock it is less solid, but is formed by the warmth of the hands. It is easily united with oil, but repels water; it is quite void of smell, and very like in substance to the Egyptian mummy. When laid on burning coals, it has the smell of sulphur tempered a little with that of naphtha, not disagreeable. There are two kinds of this mummy; the one is valuable for its scarcity and great activity. The native place of the best mummy is far from the access of men, from habitations, and from springs of water, in the province of Daraab. It is found in a narrow cave, not above two fathoms deep, cut like a well out of the mass, at the foot of the rugged mountain Caucasus."——*Kempfer. Amœn. Pers.*

This description agrees perfectly with the pissasphaltum or fossil mummy of Bua, differing only in the privation of smell, which it is difficult to imagine is totally wanting in the Persian mummy.

Pistachia.

height of 25 or 30 feet: the bark of the stem and old branches is of a dark russet colour, but that of the young branches is of a light brown. These are garnished with winged leaves, composed sometimes of two, at other times of three, pair of lobes, terminated by an odd one: these lobes approach towards an oval shape, and their edges are turned backward; and these, when bruised, emit a smell similar to that of the shell of the nut. Some of these trees produce male and others female flowers, and some have both male and female on the same tree. The male flowers come out from the sides of the branches in loose bunches or catkins. They have no petals, but five small stamina crowned by large four-cornered summits filled with farina; and when this is discharged, the flowers fall off. The female flowers come out in clusters from the sides of the branches: they have no petals, but a large oval germen supporting three reflexed styles, and are succeeded by oval nuts. 2. The lentiscus, or common mastich tree, grows naturally in Portugal, Spain, and Italy. Being an evergreen, it has been preserved in this country in order to adorn the green-houses. In the countries where it is a native, it rises to the height of 18 or 20 feet, covered with a grey bark on the stem; but the branches, which are very numerous, are covered with a reddish brown bark, and are garnished with winged leaves, composed of three or four pair of small spear-shaped lobes, without an odd one at the end. 3. The orientalis, or true mastich tree of the Levant, from which the mastich is gathered, has been confounded by most botanical writers with the lentiscus, or common mastich tree, above described, though there are considerable differences between them. The bark of the tree is brown; the leaves are composed of two or three pair of spear-shaped lobes, terminated by an odd one: the outer lobes are the largest; the others gradually diminish, the innermost being the least. These turn of a brownish colour towards the autumn, when the plants are exposed to the open air; but if they are under glasses, they keep green. The leaves continue all the year, but are not so thick as those of the common sort, nor are the plants so hardy.

Culture. The first species is propagated by its nuts, which should be planted in pots filled with light kitchen-garden earth, and plunged into a moderate hot-bed to bring up the plants: when these appear, they should have a large share of air admitted to them, and by degrees they should be exposed to the open air, which at last they will bear in all seasons, though not without great danger of being destroyed in severe winters. The second sort is commonly propagated by laying down the branches, though it may also be raised from the seed in the manner already directed for the pistachia-nut tree: and in this manner also may the true mastich-tree be raised. But this being more tender than any of the other sorts, requires to be constantly sheltered in winter, and to have a warm situation in summer.

Pistachia nuts are moderately large, containing a kernel of a pale greenish colour, covered with a reddish skin. They have a pleasant, sweet, unctuous taste, resembling that of almonds; and they abound with a sweet and well-tasted oil, which they yield in great abundance on being pressed after bruising them: they are reckoned amongst the analeptics, and are wholesome and nutritive, and are by some esteemed very proper to be prescribed by way of restoratives, eaten in small quantity, to people emaciated by long illness.

Pistil || Pisum.

PISTIL, among botanists, the little upright column which is generally found in the centre of every flower. According to the Linnæan system, it is the female part of generation, whose office is to receive and secrete the pollen, and produce the fruit. It consists of three parts, viz. germen, stylus, and stigma. See BOTANY *Index*.

PISTOIA is a city of Italy, in the duchy of Tuscany, situated on the river Stella, in a beautiful plain near the foot of the Apennine mountains. By Pliny it is called *Pistorium*, and is said to have been once a Roman colony. At present it is a bishop's see, suffragan of Florence. The streets are broad and regular, the houses tolerably well built, but poorly inhabited for want of trade. Formerly it was an independent republic, but since it was subdued by the Florentines in 1200, it has been in a declining condition. The cathedral has a very handsome cupola, and a magnificent staircase to ascend to it. In the chapel dedicated to St James, where his relics are preserved, the walls are almost covered with plates of silver. Here are four marble statues of very good workmanship. The marble pulpit, the basso-relievos, the vessel that holds the holy water, and the square steeple, are the work of John Pisano. The Jesuits have a very fine college, and the Franciscans, Dominicans, and Augustinians, good churches. In the church of Madonna dell' Umilta there are two statues, one of Leo X. and the other of Clement VII. The public palace, situated in a large square, is a handsome building; several of the nobility have also very good houses. In the neighbouring mountains, called by the name of Pistoia, there are many large villages, the chief of which is that of S. Marcello, belonging to the family of Cartoli. These mountains are a part of the Apennines, and border on the territory of Bologna and the county of Vernio; higher up is the source of the river Reno. The country about Pistoia, especially towards Florence, is exceeding fertile and delightful, covered with all sorts of fruits, corn, wine, &c. and containing a vast number of little towns, wealthy villages, and country seats, so as to be reckoned the richest and most beautiful in all Tuscany. It is about 20 miles N. W. of Florence, and 30 N. E. of Pisa, E. Long. 11. 29. N. Lat. 43. 55.

PISTOL, the smallest piece of fire-arms, borne at the saddle-bow, on the girdle, and in the pocket.

PISTOLE, a gold coin, struck in Spain and in several parts of Italy, Switzerland, &c.—The pistole has its augmentations and diminutions, which are quadruple pistoles, double pistoles, and half pistoles. See *MONEY-Table*.

PISTON, in pump-work, is a short cylinder of metal or other solid substance, fitted exactly to the cavity of the barrel or body of the pump. See HYDRODYNAMICS.

PISUM, PEASE; a genus of plants belonging to the diadelphia class. See BOTANY *Index*. The species are, 1. The sativum, or greater garden-pea, whose lower stipulæ are roundish, indented, with taper foot-stalks, and many flowers on a foot-stalk. 2. The humile, or dwarf pea, with an erect branching stalk, and leaves having two pair of round lobes. 3. The umbellatum, rose or crown-pea, with four pointed acute stipuli, and foot-stalks

Pisum. ſtalks bearing many flowers, which terminate the ſtalks. 4. The maritimum, or ſea-pea, with foot-ſtalks which are plain on their upper ſide, an angular ſtalk, arrow-pointed ſtipulæ, and foot-ſtalks bearing many flowers. 5. The Americanum, commonly called *Cape-Horn pea*, with an angular trailing ſtalk, whoſe lower leaves are ſpear-ſhaped, ſharply indented, and thoſe at the top arrow-pointed. 6. The ochrus, with membranaceous running foot-ſtalks, having two leaves and one flower upon a foot-ſtalk.

There is a great variety of garden-peaſe now cultivated in Britain, which are diſtinguiſhed by gardeners and ſeedſmen, and have their different titles; but as great part of theſe have been ſeminal variations, ſo if they are not very carefully managed, by taking away all thoſe plants which have a tendency to alter before the ſeeds are formed, they will degenerate into their original ſtate: therefore all thoſe perſons who are curious in the choice of their ſeeds, look carefully over thoſe which they deſign for ſeeds at the time when they begin to flower, and draw out all the plants which they diſlike from the other. This is what they call *roguing their peaſe;* meaning hereby the taking out all the bad plants from the good, that the farina of the former may not impregnate the latter; to prevent which, they always do it before the flowers open. By thus diligently drawing out the bad, reſerving thoſe which come earlieſt to flower, they have greatly improved their peaſe of late years, and are conſtantly endeavouring to get forwarder varieties; ſo that it would be to little purpoſe in this place to attempt giving a particular account of all the varieties now cultivated: we ſhall therefore only mention the names by which they are commonly known, placing them according to their time of coming to the table, or gathering for uſe.

The golden hotſpur.	Nonpareil.
The Charlton.	Sugar dwarf.
The Reading hotſpur.	Sickle pea.
Maſter's hotſpur.	Marrowfat.
Eſſex hotſpur.	Roſe or crown pea.
The dwarf pea.	Rouncival pea.
The ſugar pea.	Gray pea.
Spaniſh Morotto.	Pig pea; with ſome others.

The Engliſh ſea-pea is found wild upon the ſhore in Suſſex and ſeveral other counties in England, and is undoubtedly a different ſpecies from the common pea.

The fifth ſpecies hath a biennial root, which continues two years. This was brought from Cape Horn by Lord Anſon's cook, when he paſſed that cape, where theſe peaſe were a great relief to the ſailors. It is kept here as a curioſity, but the peaſe are not ſo good for eating as the worſt ſort now cultivated in Britain. It is a low trailing plant; the leaves have two lobes on each foot-ſtalk: thoſe below are ſpear-ſhaped, and ſharply indented on their edges; but the upper leaves are ſmall, and arrow-pointed. The flowers are blue, each foot-ſtalk ſuſtaining four or five flowers; the pods are taper, near three inches long; and the ſeeds are round, about the ſize of tares.

The ſixth ſort is annual. This grows naturally among the corn in Sicily and ſome parts of Italy, but is here preſerved in botanic gardens for the ſake of variety. It hath an angular ſtalk, riſing near three feet high; the leaves ſtand upon winged foot-ſtalks, each ſuſtaining two oblong lobes. The flowers are of a pale yellow colour, ſhaped like thoſe of the other ſort of pea, but are ſmall, each foot-ſtalk ſuſtaining one flower; theſe are ſucceeded by pods about two inches long, containing five or ſix roundiſh ſeeds, which are a little compreſſed on their ſides. Theſe are by ſome perſons eaten green; but unleſs they are gathered very young, they are coarſe, and at beſt not ſo good as the common pea. It may be ſown and managed in the ſame way as the garden pea. Pisum.

For an account of the method of cultivating the ſeveral ſorts of garden peaſe, ſo as to continue them throughout the ſeaſon, ſee Gardening.

The gray and other large winter peaſe are ſeldom cultivated in gardens, becauſe they require a great deal of room; they are therefore uſually ſown in fields. For the proper method of managing them, ſee Agriculture.

In the *Muſeum Ruſticum*, vol. i. p. 109. we find the following method of preparing peaſe for hog-meat, which we ſhall give in the words of the ingenious farmer who communicated it.

"A few years ago (ſays he), I had a plentiful crop of peaſe on a ten acre piece, which lies near my houſe: when they were full podded and nearly ripe, I had them hooked in the uſual manner; but before I could get them in, there came a heavy ſhower of rain which wetted them through and through; and the dull heavy weather, with frequent ſhowers which followed, prevented their drying for a conſiderable time.

"I cauſed the wads to be from time to time turned, to prevent the haulm from rotting; and at length a few days ſunſhine dried them enough to be inned; for as they lay hollow, the wind was greatly aſſiſtant to the operation.

"Before I got them in, on examining ſome of the pods, I found that the peaſe were all ſprouted to a conſiderable length: this was what I had expected, as I gave my crop over for loſt, till after a little recollection, as the weather ſtill continued fine, I determined to threſh them in the field.

"This was accordingly done; and the corn, after it was caſt and riddled to ſeparate it from the rubbiſh, was dried on my malt kiln.

"When this operation was over, I began to reflect in what manner I ſhould diſpoſe of my peaſe, being ſenſible that they could not be proper for ſeed, and ſtanding no chance of diſpoſing of them to any advantage in the market.

"At length, as it was then a time of war, and of courſe there was a great demand for pork for the uſe of the navy, I determined to buy a conſiderable number of lean hogs, that I might by their means conſume this crop on my own premiſes, and in that manner make the moſt of it.

"My expectations were more than anſwered; for I found, by repeated experience, that three buſhels of the peaſe I have mentioned went nearly as far in fattening the hogs I bought as four buſhels got in dry and hard in the manner uſually practiſed.

"This diſcovery I made ſeveral years ago, and it has turned out to my advantage; for ſince that time I have been quite indifferent as to the weather in which my peaſe are hooked, being rather better pleaſed, as far as relates to them, with wet than dry weather;

ther; but if the weather happens to be dry at the time they are ripe, I always caufe as many as I want for feeding my hogs, which are not a few in a year, to be regularly malted in the fame manner nearly as my barley: this management has of late fucceeded very well with me, and I therefore intend to continue it.

"Befides feeding my hogs with thefe malted peafe, I have often given them to my horfes, with which they agree very well, and are heartening food.

"Turkeys will fatten apace on them alfo, and be fine meat.

"I have applied my malted peafe to many other ufes, which I have not at prefent time to enumerate: but were they only ufed for feeding hogs and horfes, it is ftill worth while to prepare fome in this manner every year."

PIT-COAL, or STONE-COAL. See COAL, MINERALOGY *Index*, and COALERY.

The coal-trade is of infinite importance to Great Britain, which never could have arrived at its prefent commercial eminence without it; and this eminence it will be impoffible to retain if coal fhould ever become fcarce. This we truft is not likely to be the cafe, though Mr Williams expreffes great fears for it, and informs us that at Newcaftle and in many parts of Scotland, the mines near the fea are already wafted, the firft confequence of which muft be an enormous rife in the price. See his obfervations on this fubject in his *Natural Hiftory of the Mineral Kingdom.* This author fays, that coal was not difcovered till between the middle of the 12th and beginning of the 13th centuries: it is therefore, according to him, 400 years fince it was firft difcovered in Britain, but they have not been in common ufe for more than 200 years. The fame author makes many excellent obfervations on the appearances and indications of coal, inftructions about fearching for it, remarks on falfe and doubtful fymptoms of coal; for all which, together with his obfervations on the different kinds of Scots coal, we fhall refer our readers to the work itfelf; the firft part of which, occupying a large proportion of it, is upon the *ftrata of coal*, and on the *concomitant ftrata*. See GEOLOGY and STRATA *of the earth*.

PITAHAYA (*Cactus Pitajaya*. Lin. *Syft. Vegetabilium. Jacquin Amer.* 151. ed. 2d. p. 75. M. *E. Carthagena*), a fhrub peculiar to California, the fruit of which forms the greateft part of the harveft of the natives. Its branches are finely fluted, and rife vertically from the ftem, fo as to form a very beautiful top. The fruit is like a horfe-chefnut; in fome white, in others yellow, and in others red, but always exquifitely delicious, being a rich fweet, tempered with a grateful acid. See CACTUS, BOTANY *Index*.

PITCAIRNE, DR ARCHIBALD, an eminent phyfician and ingenious poet, was defcended from the ancient family of the Pitcairnes of Pitcairne in Fifefhire, and was born at Edinburgh on the 25th of December 1652. He commenced his ftudies at the fchool of Dalkeith; and from thence he was removed to the univerfity of Edinburgh, where he improved himfelf in claffical learning, and completed a regular courfe of philofophy. His friends, according to the authors of the *Biographia Britannica*, were defirous that he fhould follow the profeffion of theology. The unpleafant gloom, however, which at that time hung over religion and its profeffors in Scotland, could not but very ill fuit with that native cheerfulnefs of temper and liberality of mind which made him, long after, a mark for the arrows of precifenefs and grimace. The law feems to have been his own choice, and to this fcience he turned his attention. With an ardour peculiar to himfelf, and an ambition to excel in whatever he undertook, he purfued it with fo much intenfenefs, that his health began to be impaired. On this account, his phyficians advifed him to fet out for the fouth of France. By the time he reached Paris, he was happily fo far recovered, that he determined to renew his ftudies; but being informed that there was no able profeffor of law in that city, and finding feveral gentlemen of his acquaintance engaged in the ftudy of phyfic, he went with them to the lectures and hofpitals, and employed himfelf in this manner for feveral months till his affairs called him home.

On his return, he applied himfelf chiefly to the mathematics. It is not ufual to fee the briars of this fcience and the flowers of poetry growing in the fame foil. Here, however, they were happily united; and to this union perhaps was owing that fingular command of judgement, over one of the livelieft of fancies, which appears in every part of his works. His intimacy with Dr David Gregory, the celebrated mathematical profeffor, began about the fame time; and probably conduced to cherifh his natural aptitude for this ftudy. It was then in a great meafure, new to him; it foon became his principal delight; his progrefs in it was rapid, and correfpondent to his progrefs in other purfuits. His improvements on the method of infinite feries then adopted, which Dr Wallis of Oxford afterwards publifhed, were a confpicuous and early proof of his abilities in this fcience.

Had Dr Pitcairne continued to profecute the ftudy of the law, and could he have moulded his principles to the times, the firft offices and honours of the ftate might have been looked for without prefumption as the probable reward of fuch talents as he poffeffed. Struck, however with the charms of mathematical truth which had been lately introduced into the philofophy of medicine, and hoping to reduce the healing art to geometrical method, he unalterably determined on this lefs afpiring profeffion. At the period when he formed this refolution, the ideas of the medical world, already fufficiently confufed, were ftill farther jumbled by the difcovery of the circulation of the blood, which had as yet produced nothing but doubt, uncertainty, and aftonifhment. In Edinburgh at that time there was no fchool, no hofpital, no opportunity of improvement but the chamber and the fhop. He therefore foon after returned to Paris. Genius and induftry are unhappily not often united in the fame character: of fuch an union, however, Dr Pitcairne is a celebrated inftance. During his refidence in France, he cultivated the object of his purfuit with his natural enthufiafm, and with a fteadinefs from which he could not be diverted by the allurements of that joy which, in his hours of focial and feftive intercourfe, he always felt and always gave. Among his various occupations, the ftudy of the ancient phyficians feems to have had a principal fhare. This appears from a treatife which he publifhed fome time after his return; and it fhows, that he wifely determined

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to know the progrefs of medicine from its earlieft periods, before he attempted to reform and improve that fcience.

On the 13th of Auguft 1680, he received, from the faculty of Rheims the degree of Doctor; which, on the 7th of Auguft 1699, was likewife conferred on him by the univerfity of Aberdeen; both being attended with marks of peculiar diftinction. Other medical honours are faid to have been conferred on him in France and elfewhere; but nothing affords a more unequivocal teftimony to his abilities than that which the furgeons of Edinburgh gave, in admitting him, freely and unfolicited, a member of their college. None had fuch opportunities of judging of his merit as a practitioner, and on no phyfician did they ever beftow the fame public mark of refpect. Soon after his graduation at Rheims, he returned to Edinburgh; where, on the 29th of November 1681, the Royal College of Phyficians was inftituted; and his name, among others, graced the original patent from the crown.

In his *Solutio Problematis de Inventoribus*, the treatife above alluded to, he difcovers a wonderful degree of medical literature, and makes ufe of it in a manner that does great honour both to his head and his heart. His object is to vindicate Dr Harvey's claim to the difcovery of the circulation of the blood. The difcovery was, at firft, controverted by envy, and reprobated by ignorance. When at length its truth was fully eftablifhed, many invidioufly attempted to tear the laurels from the illuftrious Englifhman, and to plant them on the brows of Hippocrates and others. Had the attempt been directed againft himfelf, the generous foul of Pitcairne could not have exerted more zeal in a defence; and his arguments remain unanfwered.

During his refidence in Scotland, his reputation became fo confiderable, that, in the year 1691, the univerfity of Leyden folicited him to fill the medical chair, at that time vacant. Such an honourable teftimony of refpect, from a foreign nation, and from fuch an univerfity, cannot perhaps be produced in the medical biography of Great Britain. The luftre of fuch characters reflects honour on their profeffion, and on the country which has the good fortune of giving them birth; and ferves to give the individuals of that country not only a ufeful eftimation in their own eyes, but in thofe alfo of the reft of the world. Dr Pitcairne's well-known political principles excluded him from public honours and promotion at home: he therefore accepted the invitation from abroad; and, on the 26th of April 1692, delivered, at Leyden, his elegant and mafterly inaugural oration: *Oratio qua oftenditur medicinam ab omni philofophorum fecta effe liberam.* In this he clears medicine from the rubbifh of the old philofophy; feparates it from the influence of the different fects; places it on the broad and only fure foundation of experience; fhows how little good inquiries into the manner how medicines operate have done to the art; and demonftrates the neceffity of a fedulous attention to their effects, and to the various appearances of difeafe.

Nothing (fays an elegant panegyrift * of our author) marks a fuperiority of intellect fo much as the courage requifite to ftem a torrent of obftinately prevailing and groundlefs opinions. For this the genius and talents of Pitcairne were admirably adapted; and, in his oration, he difplays them to the utmoft. It was received with the higheft commendations; and the adminiftrators, to teftify their fenfe of fuch an acquifition to their univerfity, greatly augmented the ordinary appointment of his chair.

* Dr Chas. Webfter, in the *Harveian Oration* at Edinburgh for the year 1781; from which performance the prefent article is chiefly extracted.

He difcharged the duties of his office at Leyden fo as to anfwer the moft fanguine expectations. He taught with a perfpicuity and eloquence which met with univerfal applaufe. Independently of the encomiums of Boerhaave and Mead, who were his pupils, the numerous manufcript copies of his lectures, and the mutilated fpecimen of them † which found its way into the world without his knowledge, fhow how juftly it was beftowed. At the fame time, he was not more celebrated as a profeffor than as a practical phyfician; and notwithftanding the multiplicity of his bufinefs in both thefe characters, he found leifure to publifh feveral treatifes on the circulation, and fome other of the moft important parts of the animal economy (A).

† *Elementa Medicinæ.*

At the clofe of the feffion he fet out for Scotland, with an intention of returning in time for the fucceeding one. On his marrying (B) the daughter of Sir Archibald Stevenfon, the object of his journey, her relations would on no account confent to part with him again. He was therefore reluctantly obliged to remain; and he wrote the univerfity a polite apology, which was received with the utmoft regret. He even declined the moft flattering folicitations and tempting offers to fettle in London. Indeed he foon came into that extenfive practice to which his abilities entitled him, and was alfo appointed titular profeffor of medicine in the univerfity of Edinburgh.

The uniformity of a profeffional life is feldom interrupted by incidents worthy of record. Specimens, however, of that brilliant wit with which he delighted his friends in the hours of his leifure, continue to entertain us (C): and the effects of that eminent fkill which he exerted

(A) Dr Boerhaave gives the following character of thefe and fome other of Dr Pitcairne's differtations, which were collected and publifhed at Rotterdam, anno 1701: "Hæc fcripta optima funt et perfecta, five legas Differtationem de Motu Sanguinis per Pulmones, five alia opufcula, five ultimum tractatum de Opio." *Methodus ftudii, ab Hallero edita*, p. 569.

(B) He had been married before to a daughter of Colonel James Hay of Pitfour, by whom he had a fon and daughter, who both died young.

(C) Vide *Pitcarnii Poemata.*—Several of his poems, however, are obfcure, and fome of them totally unintelligible without a key. In thofe of them which are of a political kind, he wifhed not to exprefs himfelf too clearly; and in others, he alludes to private occurrences which were not known beyond the circle of his companions. His poem (*Ad Lindefium*), addreffed to his friend Lindfey, is commented on by the authors of the *Biographia Britannica*; and it is to be regretted that it is the only one on which they have been folicitous to throw light.

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exerted in the cure of diſeaſe, ſtill operate to the good of poſterity.

The diſcovery of the circulation, while in ſome meaſure it exploded the chemical and Galenical doctrines, tended to introduce mathematical and mechanical reaſoning in their ſtead. Of this theory (D) Dr Pitcairne was the principal ſupport, and the firſt who introduced it into Britain. A mathematical turn of mind, and a wiſh for mathematical certainty in medicine, biaſſed him in its favour, and he puſhed it to its utmoſt extent. One is at a loſs whether moſt to admire or regret ſuch a waſte of talents in propping a theory which, though ſubverſive of former ones, was to fall before others but a little more ſatisfactory than itſelf. Mechanical phyſicians expected more from geometry than that ſcience could grant. They made it the foundation inſtead of an auxiliary to their inquiries, and applied it to parts of nature not admitting mathematical calculations. By paying more attention afterwards to the ſupreme influence of the living principle, the ſource of all the motions and functions of the body, it was found that theſe could not be explained by any laws of chemiſtry or mechaniſm. They are ſtill, however, involved in obſcurity; and notwithſtanding the numberleſs improvements which have taken place in the ſciences connected with medicine, will perhaps remain inſcrutable while man continues in his preſent ſtage of exiſtence.

In a ſcience ſo ſlowly progreſſive as that of medicine, Dr Pitcairne did a great deal. By labouring in vain for truth in one road, he ſaved many the ſame drudgery, and thereby ſhowed the neceſſity of another. He not only exploded many falſe notions of the chemiſts and Galeniſts which prevailed in his time, but many of thoſe too of his own ſect. In particular, he ſhowed the abſurdity of referring all diſeaſes and their cures to an alkali or an acid (E). He refuted the idea of ſecretion being performed by pores differently ſhaped (F), Bellini's opinion of efferveſcences in the animal ſpirits with the blood, and Borelli's of air entering the blood by reſpiration (G). He proved the continuity of the arteries and veins (H); and ſeems to have been the firſt who ſhowed that the blood flows from a ſmaller capacity into a larger; that the aorta, with reſpect to the arterial ſyſtem, is the apex of a cone (I). In this therefore he may be conſidered as the latent ſpring of the diſcoveries reſpecting the powers moving the blood. He introduced a ſimplicity of preſcription unknown in pharmacy before his time (K); and ſuch was the ſtate of medicine in this country, that ſcarcely have the works of any cotemporary or preceding author been thought worthy even of preſervation (L). As to the errors of his philoſophy, let it be remembered, that no theory has as yet ſtood the teſt of many years in an enlightened period. His own hung very looſely

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light. " Some parts (ſay they) of this poem, are hardly intelligible, without knowing a circumſtance in the doctor's life, which he often told, and never without ſome emotion. It is a well known ſtory of the two Platonic philoſophers, who promiſed one another, that whichever died firſt ſhould make a viſit to his ſurviving companion. This ſtory being read by Mr Lindſey and our author together, they being both then very young, entered into the ſame engagement. Soon after, Pitcairne, at his father's houſe in Fife, dreamed one morning that Lindſey, who was then at Paris, came to him, and told him he was not dead, as was commonly reported, but ſtill alive, and lived in a very agreeable place, to which he could not yet carry him. By the courſe of the poſt news came of Lindſey's death, which happened very ſuddenly the morning of the dream. When this is known, the poem is eaſily underſtood, and ſhines with no common degree of beauty.

" Lyndeſi! Stygias jamdudum vecte per undas,
" Stagnaque Cocyti non adeunda mihi;
" Excute pauliſper Lethæi vincula ſomni,
" Ut feriant animum carmina noſtra tuum.
" Te nobis, te redde tuis, promiſſa daturus
" Gaudia; ſed proavo ſis comitante redux:
" Namque novos viros mutataque regna videbis,
' Paſſaque Teutonicas ſceptra Britanna manus *.

* Written in 1689.

" He then proceeds to exclaim againſt the principles and practices which produced this Teutonic violence upon the Britiſh ſceptre; and concludes with a wiſh, that Lindſey might bring Rhadamanthus with him to puniſh them.

" Unus abeſt ſcelerum vindex Rhadamanthus; amice,
" Dii faciant reditus ſit comes ille tui.

" Every one ſees how much keener an edge is given to the ſatire upon the Revolution, by making it an additional reaſon for his friend's keeping his promiſe to return him a viſit after his death."

(D) See the article PHYSIOLOGY.

(E) *Pitcarnii Diſſertationes*, Edin. edit. 1713. De opera quam præſtant corpora acida vel alkalica in curatione morborum.

(F) De circulatione ſanguinis per vaſa minima.

(G) De diverſa mole qua ſanguis fluit per pulmones.

(H) De circulatione ſanguinis per vaſa minima.

(I) De circulatione ſanguinis in animalibus genitis et non genitis.

(K) *Elementa Medicinæ*, lib. i. cap. 21. et paſſim.

(L) The firſt medical publication which diſtinguiſhed this country, after Dr Pitcairne's, was that of the Edinburgh Medical Eſſays, in the year 1732. Vid. the article MONRO.

loosely about him (M); and the present generally received practice differs from his very little in reality. He treated inflammatory and hemorrhagic diseases by bleeding, purging, and blistering, as has been done uniformly and solely on the different theories since. His method of administering mercury and the bark is observed at this day; and with respect to febrile, nervous, glandular, and dropsical affections, they seem to be as often the opprobriums of the art now as they were then.

Dr Pitcairne was universally considered as the first physician of his time. No one appears ever to have had so much practice in this country, or so many consultations from abroad; and no one, from all accounts, ever practised with greater sagacity and success. The highest thought themselves honoured by his acquaintance, and the lowest were never denied his assistance and advice. The emoluments of his profession must have been great; but his charities are known to have been correspondent. The possession of money he postponed to more liberal objects; he collected one of the finest private libraries in the world; which was purchased, after his death, by the Czar of Muscovy. Notwithstanding the fatigues he underwent in the exercise of his profession, his constitution was naturally delicate. About the beginning of October 1713, he became affected with his last illness; and on the 23d he died, regretted by science as its ornament, by his country as its boast, and by humanity as its friend. He left a son and four daughters: of whom only one of the latter now survives. The present noble family of Kelly are his grandchildren.

Some anonymous publications are attributed to Dr Pitcairne, particularly a treatise *De Legibus Historiæ Naturalis*, &c.; but the only ones he thought proper to legitimate are his *Dissertationes Medicæ*, and a short essay *De Salute*.

PITCAITHLY. See PITKEATHLY.

PITCH, a tenacious oily substance, drawn chiefly from pines and firs, and used in shipping, medicine, and various arts: or it is more properly tar inspissated by boiling it over a slow fire. See TAR.

Fossil PITCH. See PETROLEUM, MINERALOGY *Index*.

PITCHING, in sea-affairs, may be defined the vertical vibration which the length of a ship makes about her centre of gravity; or the movement by which she plunges her head and after-part alternately into the hollow of the sea. This motion may proceed from two causes: the waves which agitate the vessel; and the wind upon the sails, which makes her stoop to every blast thereof. The first absolutely depends upon the agitation of the sea, and is not susceptible of inquiry; and the second is occasioned by the inclination of the masts, and may be submitted to certain established maxims.

When the wind acts upon the sails, the mast yields to its effort, with an inclination which increases in proportion to the length of the mast, to the augmentation of the wind, and to the comparative weight and distribution of the ship's lading.

The repulsion of the water, to the effort of gravity, opposes itself to this inclination, or at least sustains it, by as much as the repulsion exceeds the momentum, or absolute effort of the mast, upon which the wind operates. At the end of each blast, when the wind suspends its action, this repulsion lifts the vessel; and these successive inclinations and repulsions produce the movement of pitching, which is very inconvenient; and, when it is considerable, will greatly retard the course, as well as endanger the mast, and strain the vessel.

PITH, in vegetation, the soft spongy substance contained in the central parts of plants and trees *.

* See *Plant*.

PITHO, in fabulous history, the goddess of persuasion among the Romans. She was supposed to be the daughter of Mercury and Venus, and was represented with a diadem on her head, to intimate her influence over the hearts of man. One of her arms appeared raised as in the attitude of on orator haranguing in a public assembly; and with the other she holds a thunderbolt and fetters, made with flowers, to signify the powers of reasoning and the attractions of eloquence. A caduceus, as a symbol of persuasion, appears at her feet, with the writings of Demosthenes and Cicero, the two most celebrated among the ancients, who understood how to command the attention of their audience, and to rouse and animate their various passions.—A Roman courtezan. She received this name on account of the allurements which her charms possessed, and of her winning expressions.

PITHOM, one of the cities that the children of Israel built for Pharaoh in Egypt (Exod. i. 11.) during the time of their servitude. This is probably the same city with Pathumos mentioned by Herodotus, which he places upon the canal made by the kings Necho and Darius to join the Red sea with the Nile, and by that means with the Mediterranean. We find also in the ancient geographers, that there was an arm of the Nile called *Pathmeticus*, *Phatmicus*, *Phatnicus*, or *Phatniticus*. Bochart says, that Pithom and Raamses are about five leagues above the division of the Nile, and beyond this river; but this assertion has no proof from antiquity. This author contents himself with relating what was said of Egypt in his own time. Marsham will have Pithom to be the same as Pelusium or Damietta.

PITHOU or PITHOEUS, *Peter*, a Frenchman of great literary eminence, was descended from an ancient and noble family in Normandy, and born at Troyes in 1539. His taste for literature appeared very early, and his father cultivated it to the utmost. He first studied at Troyes, and was afterwards sent to Paris, where he became first the scholar, and then the friend, of Turnebus. Having finished his pursuits in languages and the belles lettres, he was removed to Bourges, and placed under Cujacius in order to study civil law. His father was well skilled in this profession, and has left no inconsiderable

(M) Patet (*says he*) medicinam esse memoriam eorum quæ cuilibet morbo usus ostendit fuisse utilia. Nam notas non esse corporum intra venas fluentium aut consistentium naturas, adeoque sola observatione innotescere quid cuique morbo conveniat postquam sæpius eadem eidem morbo profuisse comperimus. *De Div. Morb.*

inconsiderable specimen of his judgement in the advice he gave his son with regard to acquiring a knowledge of it; which was, not to spend his time and pains upon voluminous and barren commentators, but to confine his reading chiefly to original writers. He made so rapid a progress, that at seventeen he was able to speak extempore upon the most difficult questions; and his master was not ashamed to own, that even himself had learned some things of him. Cujacius afterwards removed to Valence; and Pithœus followed him, and continued to profit by his lectures till the year 1560. He then returned to Paris, and frequented the bar of the parliament there, in order to join practical forms and usages to his theoretic knowledge.

In 1563, being then 24, he published *Adversaria Subseciva*, a work highly applauded by Turnebus, Lipsius, and other learned men; and which laid the foundation of that great and extensive fame he afterwards acquired. Soon after this, Henry III. advanced him to some considerable posts; in which, as well as at the bar, he acquitted himself most honourably. Pithœus being a Protestant, it was next to a miracle that he was not involved in the terrible massacre of St Bartholomew in 1572; for he was at Paris where it was committed, and in the same lodgings with several Hugenots, who were all killed. It seems indeed to have frightened him out of his religion; which having, according to the custom of converts, examined and found to be erroneous, he soon abjured, and openly embraced the Catholic faith. He afterwards attended the duke of Montmorency into England; and on his return, from his great wisdom, good nature, and amiable manners, he became a kind of oracle to his countrymen, and even to foreigners, who consulted him on all important occasions; and instance of which we have in Ferdinand the grand duke of Tuscany, who not only consulted him, but even submitted to his determination in a point contrary to his interests. Henry III. and IV. were greatly obliged to him for combating the League in the most intrepid manner, and for many other services, in which he had recourse to his pen as well as to other means.

Pithœus died upon his birth-day in 1596, leaving behind him a wife whom he had married in 1579, and some children. Thuanus says he was the most excellent and accomplished man of the age in which he lived; and all the learned have agreed to speak well of him. He collected a very valuable library, containing a variety of rare manuscripts, as well as printed books; and he took many precautions to hinder its being dispersed after his death, but in vain. He published a great number of works upon law, history, and classical literature; and he gave several new and correct editions of ancient writers. He was the first who made the world acquainted with the Fables of Phædrus: which, together with the name of their author, were utterly unknown and unheard of, till published from a manuscript of his.

PITISCUS, Samuel, a learned antiquary, was born at Zutphen, and was rector of the college of that city, and afterwards of St Jerome at Utrecht, where he died on the first of February 1717, aged 90. He wrote, 1. *Lexicon Antiquitatum Romanarum*, in two volumes folio; a work which is esteemed. 2. Editions of many Latin authors, with notes; and other works.

PITKEATHLY, or Pitcaithly, is the name of an estate in Strathern in Scotland, famous for its mineral waters. An intelligent traveller * gives the following account of it. "The situation of the mineral spring at Pitcaithly, the efficacy with which its waters are said to operate in the cure of the diseases for which they are used, and the accommodations which the neighbourhood affords, are all of a nature to invite equally the sick and the healthy. Two or three houses are kept in the style of hotels for the reception of strangers. There is no long-room at the well; but there are pleasing walks through the adjoining fields. Good roads afford easy access to all the circumjacent country. This delightful tract of Lower Strathern is filled with houses and gardens, and stations from which wide and delightful prospects may be enjoyed; all of which offer agreeable points to which the company at the well may direct their forenoon excursions; conversation, music, dances, whist, and that best friend to elegant, lively, and social converse, the tea-table, are sufficient to prevent the afternoons from becoming languid: and in the evenings nothing can be so delightful as a walk when the setting sun sheds a soft slanting light, and the dew has just not begun to moisten the grass.—Thus is Pitcaithly truly a rural watering-place. The company cannot be at any one time more in number than two or three families. The amusements of the place are simply such as a single family might enjoy in an agreeable situation in the country; only the society is more diversified by the continual change and fluctuation of the company." The waters of this place are of a sulphureous nature.

* Heron's *Journey through the Western Counties of Scotland.*

PITOT, Henry, of a noble family in Languedoc, was born at Aramont in the diocese of Usez, on the 29th of May 1695, and died there on the 27th of December 1771, aged 76. He learned the mathematics without a master, and went to Paris in 1718, where he formed a close friendship with the illustrious Reaumur. In 1724, he was admitted a member of the Royal Academy of Sciences at Paris, and in a few years rose to the degree of a pensioner. Besides a vast number of Memoirs printed in the collection of that society, he published in 1731 the Theory of the Working of Ships, in one volume 4to; a work of considerable merit, which was translated into English, and made the author be admitted into the Royal Society of London. In 1740, the states-general of Languedoc made choice of him for their chief engineer, and gave him at the same time the appointment of inspector general of the canal which unites the two seas. That province is indebted to him for several monuments of his genius, which will transmit his name with lustre to posterity. The city of Montpellier being in want of water, Pitot brought from the distance of three leagues the water of two springs which furnish a plentiful supply of that necessary article. They are brought to the magnificent Place du Peyron, and thence are distributed through the city. This astonishing work is the admiration of all strangers. The illustrious marshal de Saxe was the great patron and friend of Pitot, who had taught this hero the mathematics. In 1754 he was honoured with the order of St Michael. In 1735 he had married Maria Leonina Pharambier de Sabballoua, descended of a very ancient noble family of Navarre. By this marriage he had only one son, who was first advocate-general of the court of accounts, Pitot \|\| Pitt.

aids, and finances of Montpellier. Pitot was a practical philosopher, and a man of uncommon probity and candour. He was also a member of the Royal Society of Sciences of Montpellier; and his eulogium was pronounced in 1772 by M. de Râtte perpetual secretary, in presence of the states of Languedoc; as it likewise was at the Royal Academy of Sciences of Paris by Abbé de Fouchi, who was then secretary.

PITS, John, the biographer, was born in 1560, at Aulton in Hampshire, and educated at Wykeham's school, near Winchester, till he was about 18 years of age; when he was sent to New-college in Oxford, and admitted probationer fellow. Having continued in that university not quite two years, he left the kingdom as a voluntary Romish exile, and retired to Douay; thence he went to the English college at Rheims, where he remained about a year; and then proceeded to Rome, where he continued a member of the English college near seven years, and was made a priest. In 1589 he returned to Rheims; and there, during two years, taught rhetoric and the Greek language. He now quitted Rheims on account of the civil war in France; and retired to Pont à Mousson in Lorrain, where he took the degrees of master of arts and bachelor in divinity. Hence he travelled into Germany, and resided a year and a half at Triers, where he commenced licentiate in his faculty. From Triers he visited several of the principal cities in Germany; and continuing three years at Ingoldstadt in Bavaria, took the degree of doctor in divinity. Thence having made the tour of Italy, he returned once more to Lorrain; where he was patronised by the cardinal of that duchy, who preferred him to a canonry of Verdun; and about two years after he became confessor to the duchess of Cleves, daughter to the duke of Lorrain. During the leisure he enjoyed in this employment, he wrote in Latin the lives of the kings, bishops, apostolical men, and writers of England. The last of these, commonly known and quoted by this title, *De illustribus Angliæ scriptoribus*, was published after his death. The three first remain still in manuscript among the archives of the collegiate church of Liverdun. The duke of Cleves dying after Pits had been about twelve years confessor to the duchess, she returned to Lorrain, attended by our author, who was promoted to the deanery of Liverdun, which, with a canonry and officialship, he enjoyed to the end of his life. He died in 1616, and was buried in the collegiate church. Pits was undoubtedly a scholar, and not an inelegant writer; but he is justly accused of ingratitude to Bale, from whom he borrowed his materials, without acknowledgment. He quotes Leland with great familiarity, without ever having seen his book: his errors are innumerable, and his partiality to the Romish writers most obvious; nevertheless we are obliged to him for his account of several popish authors, who lived abroad at the beginning of the Reformation.

PITT, Christopher, an eminent English poet, celebrated for his excellent translation of Virgil's Æneid, was born in the year 1699. Having studied four years at New-college, Oxford, he was presented to the living of Pimperne in Dorsetshire, which he held during the remainder of his life. He had so poetical a turn, that while he was a school-boy he wrote two large folios of manuscript poems, one of which contained an entire translation of Lucan. He was much esteemed while at the university; particularly by the celebrated Dr Young, who used familiarly to call him his *son*. Next to his fine translation of Virgil, Mr Pitt gained the greatest reputation by his excellent English translation of Vida's Art of Poetry. This amiable poet died in the year 1748, without leaving, it is said, one enemy behind him.

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Pitt, *William*, earl of Chatham, a most celebrated British statesman and patriot, was born in November 1708. He was the youngest son of Robert Pitt, Esq; of Boconnock in Cornwall; and grandson of Thomas Pitt, Esq; governor of Fort St George in the East Indies, in the reign of Queen Anne, who sold an extraordinary diamond to the king of France for 135,000 l. and thus obtained the name of *Diamond Pitt*. His intellectual faculties and powers of elocution very soon made a distinguished appearance; but at the age of 16 he felt the attacks of an hereditary and incurable gout, by which he was tormented at times during the rest of his life.

His lordship entered early into the army, and served in a regiment of dragoons. Through the interest of the duchess of Marlborough he obtained a seat in parliament before he was 21 years of age. His first appearance in the house was as representative of the borough of Old Sarum, in the ninth parliament of Great Britain. In the 10th he represented Seaford, Aldborough in the 11th, and the city of Bath in the 12th; where he continued till he was called up to the house of peers in 1766. The intention of the duchess in bringing him thus early into parliament was to oppose Sir Robert Walpole, whom he kept in awe by the force of his eloquence. At her death the duchess left him 10,000 l. on condition, as was then reported, that he never should receive a place in administration. However, if any such condition was made, it certainly was not kept on his lordship's part. In 1746 he was appointed vice-treasurer of Ireland, and soon after paymaster general of the forces, and sworn a privy-counsellor. He discharged the office of paymaster with such honour and inflexible integrity, refusing even many of the perquisites of his office, that his bitterest enemies could lay nothing to his charge, and he soon became the darling of the people. In 1755 he resigned the office of paymaster, on seeing Mr Fox preferred to him. The people were alarmed at this resignation; and being disgusted with the unsuccessful beginning of the war, complained so loudly, that, on the 4th December 1756, Mr Pitt was appointed secretary of state in the room of Mr Fox afterwards Lord Holland; and other promotions were made in order to second his plans. He then took such measures as were necessary for the honour and interest of the nation; but in the month of February 1757, having refused to assent to the carrying on a war in Germany for the sake of his majesty's dominions on the continent, he was deprived of the seals on the 5th of April following. Upon this the complaints of the people again became so violent, that on the 29th of June he was again appointed secretary, and his friends filled other important offices. The success with which the war was now conducted is universally known; yet on the 5th of October 1761, Mr Pitt, to the astonishment of almost the whole kingdom, resigned the seals into his majesty's own hands. The reason of this was, that Mr Pitt,

Pitt, having received certain intelligence that the family-compact was ſigned between France and Spain, and that the latter was about to join France againſt us, thought it neceſſary to prevent her by commencing hoſtilities firſt. Having communicated this opinion in the privy-council, the other miniſters urged that they would think twice before they declared war againſt that kingdom. "I will not give them leave to think (replied Mr Pitt); this is the time, let us cruſh the whole houſe of Bourbon. But if the members of this board are of a different opinion, this is the laſt time I ſhall ever mix in its councils. I was called into the miniſtry by the voice of the people, and to them I hold myſelf anſwerable for my conduct. I am to thank the miniſters of the late king for their ſupport; I have ſerved my country with ſucceſs; but I will not be reſponſible for the conduct of the war any longer than while I have the direction of it." To this bold declaration, the lord who then preſided in council made the following reply. "I find the gentleman it determined to leave us; nor can I ſay that I am ſorry for it, ſince he would otherwiſe have certainly compelled us to leave him. But if he is reſolved to aſſume the right of adviſing his majeſty, and directing the operations of the war, to what purpoſe are we called to this council? When he talks of being reſponſible to the people, he talks the language of the houſe of commons, and forgets that at this board he is reſponſible only to the king. However, though he may poſſibly have convinced himſelf of his infallibility, ſtill it remains that we ſhould be equally convinced before we can reſign our underſtandings to his direction, or join with him in the meaſure he propoſes."

This converſation, which was followed by Mr Pitt's reſignation, is ſufficient to ſhow the haughtineſs and imperious temper of our miniſter. However, theſe very qualities were ſometimes productive of great and good conſequences, as appears from the following anecdote.—Preparatory to one of the ſecret expeditions during the war which ended in 1763 the miniſter had given orders to the different preſiding officers in the military, navy, and ordnance departments, to prepare a large body of forces, a certain number of ſhips, and a proportionable quantity of ſtores, &c. and to have them all ready againſt a certain day. To theſe orders he received an anſwer from each of the officers, declaring the total impoſſibility of a compliance with them. Notwithſtanding it was then at a very late hour, he ſent immediately for his ſecretary; and after expreſſing his reſentment at the ignorance or negligence of his majeſty's ſervants, he gave the following commands:—"I deſire, Mr Wood, that you will immediately go to Lord Anſon; you need not trouble yourſelf to ſearch the admiralty, he is not to be found there; you muſt purſue him to the gaming-houſe, and tell him from me, that if he does not obey the orders of government which he has received at my hands, that I will moſt aſſuredly impeach him. Proceed from him to Lord Ligonier; and though he ſhould be bolſtered with harlots, undraw his curtains, and repeat the ſame meſſage. Then direct your courſe to Sir Charles Frederick, and aſſure him that if his majeſty's orders are not obeyed, they ſhall be the laſt which he ſhall receive from me." In conſequence of theſe commands, Mr Wood proceeded to White's, and told his errand to the firſt lord of the admiralty; who inſiſted that the ſecretary of ſtate was out of his ſenſes, and it was impoſſible to comply with his wiſhes: "however, (added he), as madmen muſt be anſwered, tell him that I will do my utmoſt to ſatiſfy him." From thence he went to the commander in chief of the forces, and delivered the ſame meſſage. He alſo ſaid that it was an impoſſible buſineſs; "and the ſecretary knows it, (added the old lord): nevertheleſs, he is in the right to make us do what we can; and what it is poſſible to do, inform him, ſhall be done." The ſurveyor general of the ordnance was next informed of Mr Pitt's reſolution; and, after ſome little conſideration, he began to think that the orders might be completed within the time preſcribed. The conſequence at laſt was, that every thing, in ſpite of impoſſibilities themſelves, was ready at the time appointed.

After his reſignation in 1761, Mr Pitt never had any ſhare in adminiſtration. He received a penſion of 3000l. a-year, to be continued after his deceaſe, during the ſurvivancy of his lady and ſon; and this gratuity was dignified with the title of *Baroneſs of Chatham* to his lady, and that of *Baron* to her heirs male. Mr Pitt at that time declined the title of nobility; but in 1766 accepted of a peerage under the title of *Baron Pynſent and Earl of Chatham*, and at the ſame time he was appointed lord privy-ſeal.

This acceptance of a peerage proved very prejudicial to his lordſhip's character. However, he continued ſtedfaſt in his oppoſition to the meaſures of adminiſtration. His laſt appearance in the houſe of lords was on the 2d of April 1778. He was then very ill and much debilitated: but the queſtion was important, being a motion of the duke of Richmond to addreſs his majeſty to remove the miniſters, and make peace with America on any terms. His lordſhip made a long ſpeech, which had certainly overcome his ſpirits: for, attempting to riſe a ſecond time, he fell down in a convulſive fit; and though he recovered for that time, his diſorder continued to increaſe till the 11th of May, when he died at his ſeat at Hayes. His death was lamented as a national loſs. As ſoon as the news reached the houſe of commons, which was then ſitting, Colonel Barré made a motion, that an addreſs ſhould be preſented to his majeſty, requeſting that the earl of Chatham ſhould be buried at the public expence. But Mr Rigby having propoſed the erecting of a ſtatue to his memory, as more likely to perpetuate the ſenſe of his great merits entertained by the public, this was unanimouſly carried. A bill was ſoon after paſſed, by which 4000l. a-year was ſettled upon John now earl of Chatham, and the heirs of the late earl to whom that title may deſcend.—His lordſhip was married in 1754 to Lady Heſter, ſiſter to the earl of Temple; by whom he had three ſons and two daughters.

Never perhaps was any life ſo multifarious as that of Lord Chatham; never did any compriſe ſuch a number of intereſting ſituations. To bring the ſcattered features of ſuch a character into one point of view, is an arduous taſk. The author of the hiſtory of his life * has attempted to do it; and with the outlines of what he has ſaid in ſumming up his character, we ſhall finiſh our biographical ſketch of this wonderful man.

* *Hiſtory of the Life of William Pitt, Earl of Chatham.*

"One of the firſt things that ſtrikes us, in the recollection of Chatham's life, is the ſuperior figure he makes among his cotemporaries. Men of genius and attraction, a Carteret, a Townſhend, and I had almoſt ſaid

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said a Mansfield, however pleasing in a limited view, appear evidently in this comparison to shrink into narrower dimensions, and walk a humbler circle. All that deserves to arrest the attention, in taking a general survey of the age in which he lived, is comprised in the history of Chatham. No character ever bore the more undisputed stamp of originality. Unresembled and himself, he was not born to accommodate to the genius of his age. While all round him were depressed by the uniformity of fashion, or the contagion of venality, he stood aloof. He consulted no judgement but his own; and he acted from the untainted dictates of a comprehensive soul.

"The native royalty of his mind is eminently conspicuous. He felt himself born to command; and the free sons of Britain implicitly obeyed him. In him was realised the fable of Orpheus; and his genius, his spirit, his eloquence, led millions in his train, subdued the rugged savage, and disarmed the fangs of malignity and envy. Nothing is in its nature so inconsistent as the breath of popular applause: and yet that breath was eminently his during the greater part of his life. Want of success could not divert it; inconsistency of conduct could not change its tenor. The astonishing extent of his views, and the mysterious comprehension of his plans, did not in one respect set him above little things: nothing that was necessary to the execution of his designs was beneath him. In another respect, however, he was infinitely estranged to little things: swallowed up in the business of his country, he did not think of the derangement of his own private affairs; for, though indisposed to all the modes of dissipated expence, his affairs, even when his circumstances were much improved, were always deranged. But the features that seem most eminently to have characterised him, were spirit and intrepidity: they are conspicuous in every action and in every turn of his life; nor did this spirit and intrepidity leave him even at the last.

"The manners of Lord Chatham were easy and bland, his conversation was spirited and gay, and he readily adapted himself to the complexion of those with whom he associated. That artificial reserve, which is the never-failing refuge of self-diffidence and cowardice, was not made for him. He was unconstrained as artless infancy, and generous as the noon-day sun: yet had he something impenetrable that hung about him. By an irresistible energy of soul, he was haughty and imperious. He was incapable of associating councils, and he was not formed for the sweetest bands of society. He was a pleasing companion, but an unpliant friend.

"The ambition of our hero, however generous in its strain, was the source of repeated errors in his conduct. To the resignation of Lord Carteret, and again, from the commencement of the year 1770, his proceedings were bold and uniform. In the intermediate period they were marked with a versatility, incident only in general to the most flexible minds. We may occasionally trace in them the indecision of a candidate, and the suppleness of a courtier. In a word, he aimed at the impossible task of flattering at once the prejudices of a monarch, and pursuing unremittedly the interests of the people.

"A feature, too, sufficiently prominent in his character, was vanity, or perhaps pride and conscious superiority. He dealt surely somewhat too freely with invective. He did not pretend to an ignorance of his talents, or to manage the display of his important services. Himself was too often the hero of his tale; and the successes of the last war the burden of his song †.

"Patriotism was also the source of some of his imperfections. He loved his country too well; or, if that may sound absurd, the benevolence at least, that embraces the species, had not sufficient scope in his mind. He once styled himself *a lover of honourable war*; and in so doing he let us into one trait of his character. The friend of human kind will be an enemy to all war. He indulged too much a puerile antipathy to the house of Bourbon: and it was surely the want of expansive affections that led him to so unqualified a condemnation of American independency.

"But the eloquence of Lord Chatham was one of his most striking characteristics. He far outstripped his competitors, and stood alone the rival of antiquity.

"His eloquence was of every kind. No man excelled him in close argument and methodical deduction: but this was not the style into which he naturally fell. His oratory was unlaboured and spontaneous: he rushed at once upon the subject; and usually illustrated it rather by glowing language and original conception, than by cool reasoning. His person was tall and dignified; his face was the face of an eagle; his piercing eye withered the nerves, and looked through the souls of his opponents; his countenance was stern, and the voice of thunder sat upon his lips: anon, however, he could descend to the easy and the playful. His voice seemed scarcely more adapted to energy and to terror, than it did to the melodious, the insinuating, and the sportive. If, however, in the enthusiasm of admiration, we can find room for the frigidity of criticism, his action seemed the most open to objection. It was forcible, uniform, and ungraceful. In a word, the most celebrated orators of antiquity were in a great measure the children of labour and cultivation. Lord Chatham was always natural and himself."

To the misfortune of letters, and of posterity, it has been said, his lordship never published any thing. Lord Chesterfield says, "that he had a most happy turn for poetry: but it is more than probable that Chesterfield was deceived; for we are told by his biographer that his verses to Garrick were very meagre, and Lord Chatham himself said that he seldom indulged and seldom avowed it. It should seem, then, that he himself set no great value upon it. Perhaps a proper confidence of one's self is essential to all extraordinary merit. Why should we ambitiously ascribe to one mind every species of human excellence? But though he was no poet, it is more than probable, that he would have excelled as much in writing prose as he did in speaking it.

PITT, *the Right Honourable William*, was the fourth child of that illustrious orator and consummate statesman, William Pitt, the first earl of Chatham, and was born on the 28th of May 1759. Nicholas Pitt, who lived in the reign of Henry VI. was the common ancestor of the noble families of Chatham, Camelford, and Rivers. Thomas Pitt, the first of the name who attained any considerable eminence, was governor of Fort St George in the East Indies, where he purchased, as noticed in the preceding life, for 20,400l. sterling, the extraordinary diamond called the *regent*, weighing 127 carats, and which was sold to the king of France for the enormous sum of 135,000l. sterling. This diamond it is said, now occupies a conspicuous place in the imperial diadem of Bonaparte.

† Ending in 1763.

Pitt.

Bonaparte. By means of this vaſt ſum he was enabled to purchaſe a conſiderable eſtate in Cornwall; yet his grand-children were poorly provided for, particularly the great earl of Chatham, but what he wanted in opulence was abundantly ſupplied by the uncommon talents and abilities, which nature conferred upon him in the profuſeſt manner. Although he betook himſelf for ſupport to the profeſſion of arms, he never roſe higher than to the rank of a cornet of horſe, of which Sir Robert Walpole, with unexampled meanneſs, deprived him, becauſe he had the boldneſs and integrity to oppoſe his adminiſtration. This, however, proved no real obſtacle to his preferment in the ſtate, for in the year 1756 he became prime miniſter.

As the preſent earl of Chatham was deſtined for the army, and another ſon James-Charles for the navy, lord Chatham reſolved to train up William to the profeſſion of a ſtateſman. Having therefore confided the care of his other two ſons to others, he took William under his own immediate inſpection, whoſe rapid progreſs cheered the ſolitude, and illumed the declining days of this extraordinary man, who already began to preſage his future greatneſs. His ſchool exerciſes were performed under the care of a private tutor, a Mr, afterwards Dr Wilſon, while his noble father embraced every opportunity of converſing with him on every intereſting topic with the utmoſt freedom, in order to expand his mind, and mature his judgement. He alſo made him declaim from a chair or a table, well knowing that the gift of eloquence is a valuable acquiſition for a young man who wiſhes to arrive at eminence, and that it had ſupplied the deficiencies of fortune in his own perſon.

It was reſolved on, at a proper period, to ſend William to one of the univerſities, and on this occaſion Cambridge was preferred to Oxford, from a decided opinion entertained by many, that the political doctrines inculcated at the former were more liberal than thoſe uſually propagated at the latter. He was accordingly placed under the tuition of Dr Turner of Pembroke Hall. Dr Prettyman, afterwards biſhop of Lincoln, alſo participated in the care of his education, and was his private inſtructor. During his reſidence at Cambridge, it appears certain that the morals and conduct of Mr Pitt were unimpeachable, not in the ſmalleſt degree contaminated by the powerful example of the young nobility. Here he took his bachelor's degree, and alſo that of A. M. and acquired ſuch reputation in the univerſity for talents, induſtry, and propriety of deportment, as proved of great advantage to him in his ſubſequent purſuits through life.

When Mr Pitt left the univerſity, he was entered at Lincoln's Inn, much about the ſame time with Mr Addington, whoſe father had been both the phyſician and friend of his family, and was enabled to be called to the bar in the ſpace of three years, having received ſome marks of favour on account of his degree. He made choice of the weſtern circuit as the ſcene of his firſt efforts; but having little practice as an lawyer, he had of conſequence but little celebrity; and it is probable that he was ill qualified, on the ſcore of patient and laborious inveſtigation, for a purſuit in which nothing great can be accompliſhed, without the perſevering induſtry of a whole life.

Fortune at this time ſeemed eager to heap favours upon him of another kind. Being bred a ſtateſman, the houſe of commons was of courſe the place where he was to begin his political career. He was adviſed by numerous friends to propoſe himſelf a candidate for the univerſity of Cambridge, but he failed of ſucceſs from the want of ſufficient influence. Accident, however, brought about what the deſigns of his friends could not accompliſh. The duke of Rutland aſked Sir James Lowther (afterwards earl of Lonſdale), if he could poſſibly make room in any of his boroughs, to bring in his young friend Mr Pitt, who had thus loſt his election for Cambridge. He was choſen member for the borough of Appleby. About this time the American war was raging with unabated violence, which Mr Pitt, following the example and advice of his father, reprobated as one of the moſt ſhameful and ruinous conflicts of modern times. Having eſpouſed the conſtitutional and popular ſide of this important queſtion, his opening talents were diſplayed to no common advantage, and he was not only regarded as a promiſing ſpeaker, but as deſtined at ſome future period to rank high in the councils of his native country. This was truly honourable to ſo young a man, when it is remembered that one houſe could then boaſt of a Rockingham, a Richmond, and a Shelburne, and the other of a Saville, a Dunning, a Burke, a Barré, and a Fox. Yet there was ſtill room for our juvenile orator, and the recollection of the eloquence, the talents, and the meritorious ſervices of his father, contributed greatly to fix the attention of mankind on the deportment of a favourite ſon.

About this time the extent of the royal prerogative engaged the attention both of the parliament and the public, and a vote of the commons, " that the influence of the crown had increaſed, was increaſing, and ought to be diminiſhed," plainly pointed to an object, whether real or imaginary, which occaſioned a conſiderable degree of diſcontent. Mr Burke, then in the zenith of his popularity, encouraged by numerous ſymptoms of jealouſy, once more brought forward his plan of economy, which being founded on a progreſſive retrenchment, appeared admirably calculated to diminiſh the influence of the crown. It is needleſs to add that it was oppoſed by the miniſter (Lord North), but it was ably ſupported by Mr Pitt, who forcibly ridiculed every objection that could be brought againſt it. The bill was rejected after a long debate, but afterwards introduced at a more auſpicious period, and to a certain extent carried into effect.

Mr Fox having moved that miniſters ſhould immediately take every poſſible meaſure for concluding a peace with our American colonies, he was powerfully ſupported by Mr Pitt, whoſe commanding eloquence engaged the whole attention of the houſe, while he reprobated the cruelty and impolicy of the conteſt with our colonies. He declared that it was conceived in injuſtice, nurtured and brought forth in folly, and its footſteps were marked with blood, ſlaughter, perſecution, and devaſtation. Many handſome compliments were paid him by two eminent judges of real merit, we mean the lord advocate of Scotland (now Viſcount Melville), and Mr Wilkes. The former, in particular, declared that his powerful abilities and brilliant eloquence were univerſally acknowledged proofs, that the aſtoniſhing extent and force of an exalted underſtanding had deſcended, in an hereditary line, from the late illuſtrious poſſeſſor of them, to a ſon equally endowed with all the fire, and ſtrength, and grace of oratory.

Pitt.

A more equal repreſentation of the people in parliament was one of the principal objects to which the nation directed its attention, next to the American war. It was admitted to be the undoubted prerogative of the crown to declare war; but as the ſupplies were entruſted to the management of the repreſentatives of the people, it was affirmed by ſome that miniſters could not have carried on a conteſt accompanied with the waſte of ſo much blood and treaſure, had it not been owing to the corruption and venality of parliament. To derive advantage from paſt experience; to confer on the people their due importance in ſuch a mixed government as that of Britain, and reſtore the conſtitution to its original purity, became by this time the grand object of Mr Pitt's exertions. He was as yet untainted by the faſcinating charms of power and authority, and conſidered a well-earned fame as the beſt, the only reward of his laudable endeavours. He accordingly brought the principles and conduct of his opponents to ſuch a teſt as they ſucceſsfully employed againſt himſelf, in order to wound his feelings, and convict him of inconſiſtency, by turning his back on his once favourite ſentiments. When many cities and counties endeavoured to obtain a reform in parliament, Mr Pitt actually ſat in a convention of delegates, met together in the neighbourhood of the place where the legiſlature held its ſittings.

The American war in the mean time was drawing to a termination, and the ſpoils of the office of the former miniſter became the reward of thoſe who oppoſed him. During the ſhort exiſtence of the Rockingham adminiſtration, contractors were excluded from the houſe of commons; officers belonging to the cuſtoms and exciſe were declared unqualified to vote at elections; the proceedings reſpecting the Middleſex election were reſcinded: and while a more liberal policy was adopted with regard to Ireland, many ſuperfluous offices were aboliſhed in England by means of a reform bill, which tended powerfully to deſtroy corruption. Many more important reforms would have been accompliſhed, had not the death of the diſtinguiſhed Rockingham brought about great and ſudden changes.

Mr Fox retired in conſequence of new arrangements, and Lord Shelburne, as firſt lord of the treaſury, made choice of Mr Pitt as chancellor of the exchequer, who, declared, although only 23 years of age, that he would accept of no inferior office. Peace now ſeemed to be an object generally deſirable at any rate, and without much regarding what ſacrifices might be made in order to procure it; but the terms met with powerful oppoſition from two men formerly conſidered as mortal enemies, viz. Lord North and Mr Fox, the latter of whom retired from office. Soon after the diſmiſſion of Mr Fox, Mr Pitt again brought forward the queſtion reſpecting a reform in parliament, which he fondly hoped would be the means of reſtoring him to his wonted popularity, and pave the way to the increaſe of his power. He therefore ſubmitted three different motions to the conſideration of the houſe; but although in theſe motions he was ably ſupported, he was left in a minority.

The coalition miniſtry, as it was called, had ſtill a conſiderable majority in parliament, notwithſtanding the popularity belonging to the name and talents of Mr Pitt, but the celebrated India bill was productive of a change. This bill owed its origin to Mr Burke, but it received a regular and ſyſtematical oppoſition from the ex-chancellor of the exchequer. It was carried, however, in the houſe of commons by a great majority, but in the houſe of lords it was oppoſed by the duke of Richmond, Lord Thurlow, and Earl Temple (afterwards marquis of Buckingham); and on the 17th of December 1783, it was finally rejected by a majority of 19.

Pitt.

The king in the mean time determined on an entire change of adminiſtration, and the two ſecretaries were informed on the 18th of December 1783, about 12 o'clock at night, that his majeſty had no further occaſion for their ſervices. In conſequence of this change, the important offices of firſt lord of the treaſury and chancellor of the exchequer were beſtowed on Mr Pitt, who thus became prime miniſter before he was full 24 years of age. Thurlow was created lord chancellor, the duke of Richmond keeper of the privy ſeal; the marquis of Caermarthen and Lord Sidney were choſen ſecretaries of ſtate, and Mr Dundas, treaſurer of the navy.

Much about this time Mr Pitt brought forward a new bill for the better government of India. He propoſed that a board of controul ſhould be inſtituted, the nomination of whoſe members was to be veſted in the crown, and to them the diſpatches of the company were to be ſubmitted. He alſo propoſed that the appointment of the commander in chief ſhould belong to his majeſty, and having thus ſecured the political intereſts of the company, he left thoſe of a commercial nature entirely to the court of directors. This bill, after a ſhort debate, was rejected by a majority of eight. Such was the preſent temper of the houſe of commons, that a coalition or immediate diſſolution became abſolutely neceſſary; and the former having been unſucceſsfully attempted, the latter was ſuddenly adopted, on the 25th of March 1784. Mr Pitt having been returned for the univerſity of Cambridge, again brought forward his bill in an amended ſtate for the regulation of India, and carried it in triumph through both houſes of parliament. The remaining part of the ſeſſion gave birth to an act for the better prevention of ſmuggling, and the commutation act, by virtue of which certain duties were transferred from tea to windows.

When Mr Alderman Sawbridge (June 16th 1784) made a motion for inquiring into the preſent ſtate of the commons of Great Britain in parliament, Mr Pitt, whoſe political ſentiments had undergone a revolution, felt himſelf conſiderably embarraſſed, as he was reminded that he had brought forward queſtions on the ſame ſubject upon a former occaſion. Mr Pitt, however, declined it, on account of the preſſure of public buſineſs, and obſerved that, in his opinion, the preſent was not the proper time for bringing forward the queſtion, and that it might be urged with greater probability of ſucceſs on ſome future occaſion. He did not wiſh it to be diſcuſſed in a precipitate manner, yet the buſineſs itſelf ſhould have every ſupport he was able to afford it.

Having now attained the ſummit of power and influence as prime miniſter, Mr Pitt exerciſed every function of his important office, without any check or controul. Poſſeſſed of a great majority in both houſes of parliament, as well as in the cabinet, his whole deportment, in the language of his opponents, ſeems to have become lofty in the extreme; and he paid little or no regard to that popularity which he had formerly courted.

A commercial treaty about this time was entered into with France, the terms of which have been generally acknowledged

acknowledged to be advantageous to Britain. Mr Pitt, who deserves great credit for giving the plan his countenance, adopted, much about the same time, another respecting the finances, from which he derived a high degree of reputation; and, as he pointed at a period when the national debt might, in all probability, be extinguished, the country, if it was not altogether satisfied, appeared to be at least contented under his administration: and it is not a little to the credit of his financial system, that his opponents, when in power, not only approved, but adopted and extended it.

In this manner a commercial country began again to flourish, by turning its attention to the arts of peace; but, during his administration, its prosperity was threatened to be interrupted by the preparations for an attack upon Russia at one time, and by an open rupture with Spain at another, relative to Nootka sound. In both cases the blow was warded off by negociation, and a good understanding restored. The restoration of the stadtholder, by the intervention of a Prussian army, and his strenuous opposition of the prince of Wales's appointment to the regency during the king's indisposition, were also two important measures pursued and discussed in the course of his ministry.

Soon after the commencement of the French revolution, Mr Pitt deemed a war with that country inevitable. But for a full detail of the events of this war, see Britain. Having held the reins of government during 18 years, Mr Pitt, and all the members of the cabinet, suddenly retired from office in 1801. On this occasion all parties appeared to rejoice at the appointment of Mr Addington; and France, from that moment, as some assert, seemed to have neither friends nor advocates in this island. When the articles of the treaty of Amiens were debated in the house of commons, Mr Pitt defended the new minister with the whole force of his abilities and influence.

On the 15th of March 1804, Mr Pitt made a direct attack on the administration; and the admiralty board was accused by him of imbecility. He zealously supported Mr Fox's proposition relative to the Irish militia bill for the national defence, which was lost on a division. The minister's majority having dwindled to 37, on the army of reserve suspension bill, Mr Addington and some of his friends retired, and the ex-minister resumed his former seat. When parliament met on the 15th of January 1805, Mr Pitt warmly defended the war with Spain; and, on the motion for an address, he had a majority of 207.

But, in the mean time, a gouty habit, the predisposing causes of which appear to have been hereditary, and which, perhaps, was increased by his own manner of living, seized on a constitution never very strong. It is alleged, by his opponents, that this, combined with the miscarriage of his schemes, and the aspect of affairs on the continent, preyed so much upon his mind, that he is said to have died of a broken heart, at his house near Putney, between four and five on Wednesday morning, January 23. 1806, in the 47th year of his age.

As a financier, no man has obtained more praise, who ever presided at the board of exchequer. During his ministry some of our manufactures languished, but many flourished, and our exports were greatly increased. As a speaker he was unrivalled, and his generous scorn of wealth must be admired. In 20 years his debts amounted only to 40,000l. They were paid out of the public purse. The house of commons also passed a vote, that the expences of his funeral, and a monument to his memory, should be defrayed by the nation.

PITTACUS, a native of Mitylene in Lesbos, was one of the seven wise men of Greece: his father's name was Hyrradius. With the assistance of the sons of Alcæus, he delivered his country from the oppression of the tyrant Melanchrus; and in the war which the Athenians waged against Lesbos, he appeared at the head of his countrymen, and challenged to single combat Phrynon the enemy's general. As the event of the war seemed to depend upon this combat, Pittacus had recourse to artifice; and when he engaged, he entangled his adversary in a net which he had concealed under his shield, and easily dispatched him. He was amply rewarded for this victory; and his countrymen, sensible of his merit, unanimously appointed him governor of their city with unlimited authority. In this capacity Pittacus behaved with great moderation and prudence; and after he had governed his fellow-citizens with the strictest justice, and after he had established and enforced the most salutary laws, he voluntarily resigned the sovereign power after having enjoyed it for 10 years, observing that the virtues and innocence of private life were incompatible with the power and influence of a sovereign. His disinterestedness gained him many admirers; and when the Mityleneans wished to reward his public services by presenting him with an immense tract of territory, he refused to accept more land than what should be contained in the distance to which he could throw a javelin. He died in the 70th year of his age, about 579 years before Christ, after he had spent the last 10 years of his life in literary ease and peaceful retirement.

The following maxims and precepts are ascribed to Pittacus: The first office of prudence is to foresee threatening misfortunes, and prevent them. Power discovers the man. Never talk of your schemes before they are executed; lest, if you fail to accomplish them, you be exposed to the double mortification of disappointment and ridicule. Whatever you do, do it well. Do not that to your neighbour which you would take ill from him. Be watchful for opportunities.

Many of his maxims were inscribed on the walls of Apollo's temple at Delphi, to show to the world how great an opinion the Mityleneans entertained of his abilities as a philosopher, a moralist, and a man. By one of his laws, every fault committed by a man when intoxicated deserved double punishment.

PITTENWEEM, a small town situated on the frith of Forth, towards the eastern extremity of the county of Fife in North Britain. It takes its name from a small cave in the middle of it, anciently called a *weem;* and is remarkable for nothing but the ruins of a religious house, which is sometimes called an *abbey* and sometimes a *priory*. Which of these is the proper denomination it is hardly worth while to inquire; but it appears from the arms of the monastery, still preserved over the principal gate, that the superior, by whatever title he was called, had the privilege of wearing a mitre. This edifice, which seems never to have been large, was, with other monuments of mistaken piety, alienated from the church at the Reformation; and what parts of it now remain are

Pittenweem.

are put to very different uses. Some of the cells of the monks furnish habitations tolerably convenient for the servants of him who, in the ceaseless change of property, has got possession of the lands which formerly belonged to them. That which seems to have been the granary is a decent parish church. The porch of the chapel, the only part of that building which exists, has been alternately employed as a stable and a slaughter-house; and the meat killed there has been commonly exposed to sale in the lower part of the steeple of that edifice which is now dedicated to the offices of parochial devotion. Had the moralizing traveller *, who composed the beautiful and pathetic meditation on the ruins of *Iona*, condescended to visit Pittenweem, he would not have viewed the abbey without emotion. Insignificant as the place at present is, it seems to have been of some consequence in the last century; and we are led to infer, from the following extract from the records, that the inhabitants were opulent, and that the town was fortified.

* Johnson.

"Pittenweem, decimo quarto Feb. 1651. The bailies and council being convened, and having received information that his majesty is to be in progress with his court along the coast to-morrow, and to stay at Anstruther house that night, have thought it expedient, according to their bounden duty, with all reverence and due respect, and with all the same solemnity they can, to wait upon his majesty, as he comes through this his majesty's burgh, and invite his majesty to eat and drink as he passes; and for that effect hath ordained, that the morn afternoon the town's colours be put upon the bertisene of the steeple, and that at three o'clock the bells begin to ring, and ring on still till his majesty comes hither, and passes to Anstruther: And sicklike, that the minister be spoken to, to be with the bailies and council, who are to be in their best apparel, and with them a guard of 24 of the ablest men, with partizans, and other 24 with muskets, all in their best apparel, William Sutherland commanding as captain of the guard; and to wait upon his majesty, and to receive his highness at the West Port, bringing his majesty and court through the town, until they come to Robert Smith's yeet, where an table is to be covered with my Lord's * best carpet: and that George Hetherwick have in readiness, of fine flour, some great bunns, and other wheat-bread of the best order, baken with sugar, cannell, and other spices fitting; and that James Richardson and Walter Airth have care to have ready eight or ten gallons of good strong ale, with Canary, sack, Rhenish wine, tent, white and claret wines, that his majesty and his court may eat and drink; and that in the mean time, when his majesty is present, the guard do diligently attend about the court; and so soon as his majesty is to go away, that a sign be made to Andrew Tod, who is appointed to attend the colours on the steeple head, to the effect he may give sign to those who attend the cannon of his majesty's departure, and then the *haill thirty-six cannons to be all shot at once*. It is also thought fitting, that the minister, and James Richardson the oldest bailie, when his majesty comes to the table, show the great joy and sense this burgh has of his majesty's condescendence to visit the same, with some other expressions of loyalty. All which was acted." The population of this town, in 1790, was computed at 1157. N. Lat. 56. 11. W. Long. 2. 49.

* The Earl of Kelly.

Pittosporum || Pius.

PITTOSPORUM, a genus of plants belonging to the pentandria class. See Botany *Index*.

PITUITARY GLAND. See Anatomy *Index*.

PITYOCAMPASIS, in *Entomology*, the caterpillar of the pine-tree, received its compound name from that substance. It was considered as a poison, and as a remedy, according to its different mode of application. Our chief information, concerning this caterpillar, is derived from M. Reaumur, who has attentively observed its manner of life. The animal cannot bear much cold, and is therefore never found in the higher latitudes. It is styled processionary, because it never leaves its hold, where many families reside, till the evening, when it feeds in trains, led on by two or three, and this train leaves a ribband of silk in its way; for those behind follow exactly the steps of those which preceded, and each leaves its fibre of silk. Their nests are found in autumn; they are produced in the middle of September, become torpid in December, and recover their strength again in spring. They then descend from the trees, plunge into the earth, and undergo their last change. It is the bombix pityocampa of Fabricius, (*Mantissa Insector*. tom. ii. p. 114. N° 66.), and greatly resembled the processionary caterpillar of the oak. The ancients used it as a vesicatory, and the acrimony seems to reside chiefly in a dust which is concealed in receptacles on its back. This is its offensive weapon, for it is thrown out at will, and produces very troublesome effects, though the hair of the animal and every part of its body seem to have a similar, but weaker power. The effect is also weaker in winter; but this may depend on the diminished irritability of the human body, as well as on the torpid state of the insect. Their silk is not sufficiently strong for the loom, and in hot water melts almost to a paste. In the earth it forms nests of stronger silk, but it is then found with difficulty: in boxes its silk is extremely tender. Adding to all these inconveniences, handling the cones produces all the bad effects of the dust. Matthiolus recommends them as a styptic, and perhaps they may serve for burning on the skin instead of moxa, the downy silk of a species of artemisia. The ancients, afraid of its hurtful qualities, used them with caution, and enacted laws against their being sold promiscuously: the modern planter is chiefly afraid of them, because they destroy the beauty of his trees, and he endeavours to collect the eggs by cutting off the branches, which are burnt immediately.

PIVAT, or Pivot, a foot or shoe of iron or other metal, usually conical or terminating in a point, whereby a body, intended to turn round, bears on another fixed at rest, and performs its revolutions. The pivot usually bears or turns round in a sole, or piece of iron or brass hollowed to receive it.

PIUS II. (Æneas-Sylvius Piccolomini), was born on the 18th of October 1405, at Corsigni in the Sienese, the name of which he afterwards changed into that of *Pienza*. His mother Victoria Forteguerra, when she was with child of him, dreamed that she should be delivered of a mitred infant; and as the way of degrading clergymen at that time was by crowning them with a paper mitre, she believed that Æneas would be a disgrace to his family. But what to her had the appearance of being a disgrace, was a presage of the greatest honours. Æneas was carefully educated, and made considerable proficiency in the belles lettres. After having

ving finished his studies at Sienna, he went in 1431 to the council of Bale with Cardinal Capranica, surnamed *De Fermo*, because he was entrusted with the government of that church. Æneas was his secretary, and was then only 26 years of age. He afterwards acted in the same capacity to some other prelates, and to Cardinal Albergati. The council of Bale honoured him with different commissions, in order to recompense him for the zeal with which he defended that assembly against Pope Eugene IV. He was afterwards secretary to Frederic III. who decreed to him the poetic crown, and sent him ambassador to Rome, Milan, Naples, Bohemia, and other places. Nicholas V. advanced him to the bishopric of Trieste, which he quitted some time after for that of Sienna. At last, after having distinguished himself in various nunciatures, he was invested with the Roman purple by Calixtus III. whom he succeeded two years after, on the 27th of August 1458. Pius II. now advanced to the holy see, made good the proverb, *Honores mutant mores*. From the commencement of his pontificate, he appeared jealous of the papal prerogatives. In 1460 he issued a bull, "declaring appeals from the pope to a council to be null, eroneous, detestable, and contrary to the sacred canons." That bull, however, did not prevent the procurator-general of the parliament of Paris from appealing to a council in defence of the Pragmatic Sanction, which the pope had strenuously opposed. Pius was then at Mantua, whither he had gone in order to engage the Catholic princes to unite in a war against the Turks. The greater part of them had agreed to furnish troops or money; others refused both, particularly France, who from that moment incurred his holiness's aversion. That aversion abated under Louis XI. whom he persuaded in 1461 to abolish the Pragmatic Sanction, which the parliament of Paris had supported with so much vigour.

The following year 1462, was rendered famous by a controversy which took place between the Cordeliers and Dominicans, whether or not the blood of Jesus Christ was separated from his body while he lay in the grave. It was also made a question whether it was separated from his divinity. The Cordeliers affirmed that it was, but the Dominicans were of an opposite opinion. They called each other heretics; which obliged the pope to issue a bull, forbidding them under pain of censure to brand one another with such odious epithets. The bull which his holiness published on the 26th of April, retracting what he had written to the council of Bale when he was its secretary, did not redound much to his honour. "I am a man (says he), and as a man I have erred. I am far from denying that a great many things which I have said and written may deserve condemnation. Like Paul, I have preached through deception, and I have persecuted the church of God through ignorance. I imitate the blessed Augustin, who having suffered some erroneous sentiments to creep into his works, retracted them. I do the same thing; I frankly acknowledge my ignorance, from a fear lest what I have written in my younger years should be the occasion of any error that might afterwards be prejudicial to the interests of the holy see. For if it be proper for any one to defend and support the eminence and glory of the first throne of the church, it is in a peculiar manner my duty, whom God, out of his mercy and goodness alone, without any merit on my part, has raised to the dignity of *vicar of Jesus Christ*. For all these reasons, we exhort and admonish you in the Lord, not to give credit to those writings of ours which tend in any degree to hurt the authority of the apostolic see, and which establish opinions that are not received by the Roman church. If you find, then, any thing contrary to her doctrine, either in our dialogues, in our letters, or in other of our works, despise these opinions, reject them, and adopt our present sentiments. Believe me rather now that I am an old man, than when I addressed you in my earlier days. Esteem a sovereign pontiff more than a private person; except against Æneas Sylvius, but receive Pius II." It might be objected to his holiness, that it was his dignity alone which had made him alter his opinion. He anticipates that objection, by giving a short account of his life and actions, with the whole history of the council of Bale, to which he went with Cardinal Capranica in 1431; "but (says he) I was then a young man, and without any experience, like a bird just come from its nest." In the mean time, the Turks were threatening Christendom. Pius, ever zealous in the defence of religion against the infidels, forms the resolution of fitting out a fleet at the expence of the church, and of passing over into Asia himself, in order to animate the Christian princes by his example. He repaired to Ancona with a design to embark; but he there fell sick with the fatigue of the journey, and died on the 16th of August 1464, aged 59 years. Pius was one of the most learned men of his time, and one of the most zealous pontiffs; but being of an ambitious and pliant disposition, he sometimes sacrificed to that ambition. His principal works are, 1. Memoirs of the council of Bale, from the suspension of Eugenius to the election of Felix. 2. The history of the Bohemians, from their origin to the year 1458. 3. Two books on cosmography. 4. The history of Frederic III. whose vice-chancellor he had been. This performance was published in 1785 in folio, and is believed to be pretty accurate and very particular. 5. A treatise on the education of children. 6. A poem upon the passion of Jesus Christ. 7. A collection of 432 letters, printed at Milan, 1473, in folio, in which are found some curious anecdotes. 8. The memoirs of his own life, published by John Gobelin Personne his secretary, and printed at Rome in 4to in 1584. There is no doubt of this being the genuine production of that pontiff. 9. *Historia rerum ubicumque gestarum*, of which only the first part was published at Venice in 1477 in folio. His works were printed at Helmstadt in 1700, in folio, at the beginning of which we find his life. That verse of Virgil's Æneid (lib. i. 382.) which begins thus,

Sum pius Æneas,——

and the end of the following verse,

——*fama super æthera notus*,

have been applied to him.

Pius IV. (*John Angel, Cardinal de Medicis*), of a different family from that of Florence, was born at Milan in 1499. He was son to Bernardin de Medechini, and brother of the famous Marquis de Marignan, Charles V.'s general. He raised himself by his own merit, and filled several important offices under Popes Clement VII. and Paul III. Julius III. who had entrusted him with several legations, honoured him with a cardinal's hat in 1549. After the death of Paul IV. he was advanced to St Peter's chair on the 25th of December 1559. His predeceſſor had rendered himſelf deteſtable to the Romans, who treated his memory with every mark of indignity, and Pius IV. commenced his pontificate by pardoning them. He did not, however, extend the ſame clemency to the nephews of Pope Paul IV.; for he cauſed Cardinal Caraffe to be ſtrangled in the caſtle of St Angelo, and his brother, the prince de Palliano, to be beheaded. His zeal was afterwards directed againſt the Turks and heretics. In order to ſtop, if poſſible, the progreſs of theſe laſt, he renewed the Council of Trent, which had been ſuſpended. He knew well (ſays Abbe de Choiſy), that that council might make ſome regulations which would have the effect to leſſen his authority; but, on the other hand, he perceived that great inconveniences might reſult from its not being aſſembled; and "*in the main* (ſaid he to his confidants) *it is better to feel evil for once than to be always in dread of it.*" In 1561 he diſpatched nuncios to all the Catholic and Proteſtant princes, to preſent them with the bull for calling that important aſſembly. An end was, however, put to it by the induſtry of his nephew, S. Charles Borromeus, in 1563; and, on the 26th of January the year following, he iſſued a bull for confirming its decrees. In 1565 a conſpiracy was formed againſt his life by Benedict Acolti, and ſome other viſionaries. Thoſe madmen had taken it into their head that Pius IV. was not a lawful pope, and that after his death they would place another in St Peter's chair, with the title of *Pope Angelicus*, under whom errors might be reformed, and peace reſtored to the church. The conſpiracy was diſcovered, and the fanatic Benedict put to death. This pontiff died a little time after, on the 9th of December 1565, aged 66 years, carrying to the grave with him the hatred of the Romans, whom his ſeverities had exaſperated. He was a man of great addreſs, and very fruitful in his reſources. He adorned Rome with ſeveral public edifices; but theſe ornaments tended greatly to impoveriſh it. If he was the inſtrument of raiſing his relations in the world, it muſt be allowed, at leaſt, that the greater part of them did him honour.

Pius V. (*S. Michael Ghiſleri*), born at Boſchi or Boſco, in the dioceſe of Fortona, on the 17th of January 1504, was, according to Abbé de Choiſy, ſon to a ſenator of Milan. He turned a Dominican friar. Paul IV. informed of his merit and virtue, gave him the biſhopric of Sutri, created him cardinal in 1557, and made him inquiſitor-general of the faith among the Milaneſe and in Lombardy; but the ſeverity with which he exerciſed his office obliged him to quit that country. He was ſent to Venice, where the ardour of his zeal met with ſtill greater obſtacles. Pius IV. added to the cardinal's hat the biſhopric of Mondovi. After the death of that pontiff, he was advanced to St Peter's chair in 1566. The Romans expreſſed but little joy at his coronation: he was very ſenſible of it, and ſaid, "*I hope they will be as ſorry at my death as they are at my election;*" but he was miſtaken. Raiſed by his merit to the firſt eccleſiaſtical preferment in Chriſtendom, he could not diveſt himſelf of the ſeverity of his character; and the ſituation in which he found himſelf rendered, perhaps, that ſeverity neceſſary. One of his firſt objects was to repreſs the luxury of the clergy, the pride of the cardinals, and the licentious manners of the Romans. He cauſed the decrees of reformation enacted by the Council of Trent to be put in execution; he prohibited bull-baiting in the Circus; he expelled from Rome the women of the town; and allowed the cardinals to be proſecuted for their debts. The errors which overflowed the Chriſtian world gave him great uneaſineſs. After having employed gentle and lenient meaſures in the reclaiming of heretics, he had recourſe to ſeverity, and ſome of them ended their days in the flames of the inquiſition. He particularly diſplayed his zeal for the grandeur of the holy ſee in 1568, by ordaining that the bull *In cœna domini*, which was publiſhed at Rome every year on *Maunday Thurſday*, and which Clement XIV. ſuppreſſed, ſhould be publiſhed likewiſe throughout the whole church. That bull, the work of ſeveral ſovereign pontiffs, principally regards the juriſdiction of the eccleſiaſtical and civil power. It anathematizes thoſe who appeal from the decrees of popes to a general council; thoſe who favour the appellants; the univerſities which teach that the pope is ſubject to a general council; the princes who would reſtrain the eccleſiaſtical juriſdiction, or who exact contributions from the clergy. It was rejected by all the ſovereign ſtates, excepting a very few. In 1580, ſome biſhops having endeavoured to introduce it into their dioceſes, the parliament cauſed their temporalities to be ſeized upon, and declared thoſe guilty of high treaſon who ſhould imitate the fanaticiſm of thoſe prelates. Pius V. for ſome time meditated an expedition againſt the Turks. He had the courage to make war on the Ottoman empire, by forming a league with the Venetians and Philip II. king of Spain. This was the firſt time that the ſtandard of the two keys was ſeen diſplayed againſt the creſcent. The naval armies came to an engagement, on the 7th of October 1571, in Lepanto bay, in which the confederate Chriſtian princes obtained a ſignal victory over the Turks, who loſt above 30,000 men, and near 200 galleys. This ſucceſs was principally owing to the pope, who exhauſted both his purſe and perſon in fitting out that armament. He died of the gravel ſix months after, on the 30th of April 1572, aged 68. He repeated often, in the midſt of his ſufferings, "*O Lord! increaſe my pains and my patience.*" His name will for ever adorn the liſt of Roman pontiffs. It is true, that his bull againſt Queen Elizabeth, and his other bull in favour of the inquiſition, with his rigorous proſecution of heretics both in France and Ireland, prove that he had more zeal than ſweetneſs in his temper; but in other reſpects he poſſeſſed the virtues of a ſaint and the qualities of a king. He was the model of the famous Sixtus Quintus, to whom he gave an example of amaſſing in a few years ſuch ſavings as were ſufficient to make the holy ſee be regarded as a formidable power. Sultan Selim, who had no greater enemy than this pope, cauſed public rejoicings to be made at Conſtantinople for his death during the ſpace of three days. The pontificate of Pius is alſo celebrated for the condemnation of Baius, the extinction of the order of Humilies, and the reformation of that of the Ciſtercians. He was canonized by Clement XI. in 1712. There are extant ſeveral of his letters, printed at Anvers in 1640, in 4to. Felibian, in 1672, publiſhed his *Life*, tranſlated from the Italian of Agatio di Somma; but we cannot vouch for the fidelity of the tranſlation.

PIX. See *MINT-Marks*.

PIZARRO, FRANCIS, a celebrated Spanish general, the discoverer and conqueror of Peru, in conjunction with Diego Almagro, a Spanish navigator. They are both charged with horrid cruelties to the inhabitants; and they fell victims to their own ambition, jealousy, and avarice. Almagro revolting, was defeated and beheaded by Pizarro, who was assassinated by Almagro's friends in 1541. See PERU.

PLACE, LOCUS, in *Philosophy*, a mode of space or that part of immoveable space which any body possesses. See METAPHYSICS, N° 185.

PLACE, in *Astronomy*. The place of the sun, a star, &c. denotes the sign and degree of the zodiac which the luminary is in; or the degree of the ecliptic, reckoning from the beginning of Aries, which the planet's or star's circle of longitude cuts: and therefore coincides with the longitude of the sun, planet, or star. As the sine of the sun's greatest declination 23° 30′: to the sine of any present declination given or observed, for instance, 23° 15′ : : so is the radius 10 : to the sine of his longitude 81° 52′; which, if the declination were north, would give 20° 52′ of Gemini; if south, 20° 52′ of Capricorn, for the sun's place. See DECLINATION, &c.

The place of the moon being that part of her orbit wherein she is found at any time, is of various kinds, by reason of the great inequalities of the lunar motions, which render a number of equations and reductions necessary before the just point be found. The moon's fictitious place is her place once equated; her place nearly true, is her place twice equated; and her true place thrice equated. See ASTRONOMY, *passim*.

PLACE, in *War*, a general name for all kinds of fortresses where a party may defend themselves. Thus, 1. A strong or fortified place is one flanked, and covered with bastions. 2. A regular place, one whose angles, sides, bastions, and other parts, are equal; and this is usually denominated from the number of its angles, as a pentagon, hexagon, &c. 3. Irregular place is one whose sides and angles are unequal.—4. Place of arms is a strong city or town pitched upon for the chief magazine of an army; or, in a city or garrison, it is a large open spot of ground, usually near the centre of the place where the grand guard is commonly kept, and the garrison holds its rendezvous at reviews, and in cases of alarm to receive orders from the governor. 5. Places of arms of an attack, in a siege, is a spacious place covered from the enemy by a parapet or epaulement, where the soldiers are posted ready to sustain those at work in the trenches against the soldiers of the garrison. 6. Place of arms particular, in a garrison, a place near every bastion, where the soldiers sent from the grand place to the quarters assigned them relieve those that are either upon the guard or in fight. 7. Place of arms without, is a place allowed to the covert way for the planting of cannon, to oblige those who advance in their approaches to retire. 8. Place of arms in a camp, a large place at the head of the camp for the army to be ranged in and drawn up in battalia. There is also a place for each particular body, troop, or company, to assemble in.

Common-PLACE. See *COMMON-Place*.

PLACENTA, in *Anatomy* and *Midwifery*, a soft roundish mass, found in the womb of pregnant women; which, from its resemblance to the liver, was called by the ancients *hepar uterinum*, uterine liver.

PLACENTIA, called by the natives *Piacenza*, is a town of Italy, and capital of a duchy of the same name, with a bishop's see. It is seated about 100 paces from the river Po, in a very fertile pleasant plain, watered by a great number of rivulets, and surrounded with hills, abounding in all sorts of fruits. In its territory there are salt-springs, from which they make a very white salt; and there are also mines of iron, woods, and warrens. It contains a great number of merchants, and is reckoned three miles in circumference. Its fortifications are inconsiderable, but the citadel is pretty strong. The streets are straight, and the principal street called *Stradone*, is 25 common paces broad and 3000 feet long, in a direct line, with 600 stone posts, for separating the foot from the carriage-way, and on both sides are 11 spacious convents. The other buildings of the city are not very remarkable, though it contains 45 churches, 28 convents, and two alms-houses. The cathedral is pretty much in the Gothic taste; but the church of the Augustines is reckoned the most beautiful, and esteemed worthy of its architect, the celebrated Vignoli. The ducal palace, though large, makes no great appearance externally; but within there are some good apartments. In the area before the town-house stand two admirable brass statues of Alexander and Renatus IV. both of the house of Farnese, and dukes of Parma and Placentia. The bishop is suffragan to the archbishop of Milan. At this city begins the Via Æmilia, which extends as far as Rimini on the Adriatic. The number of the inhabitants is about 30,000, among whom there are 2000 ecclesiastics. This city has been taken several times in the wars of Italy. The king of Sardinia took possession of it in 1744, it being ceded to him by the queen of Hungary; but it was taken from him in 1746, after a bloody battle. The French got possession of it in 1796. It has a famous university, and the inhabitants are much esteemed for their politeness. There is a great fair here every year on the 15th of April, which is much frequented. Placentia is about 32 miles north-west of Parma and 83 east of Turin. E. Long. 10. 24. N. Lat. 45. 5.

PLAGIARY, in *Philology*, the purloining another man's works, and putting them off as our own. Among the Romans, *plagiarius* was properly a person who bought, sold, or retained a freeman for a slave; and was so called, because, by the Flavian law, such persons were condemned *ad plagas*, "to be whipped."

Thomasius has an express treatise *De plagio literario;* wherein he lays down the laws and measures of the right which authors have to one another's writings.—"Dictionary writers, at least such as meddle with *arts and sciences* (as is pertinently observed by Mr Chambers), seem exempted from the common laws of *meum* and *tuum:* they do not pretend to set up on their own bottom, nor to treat you at their own cost. Their works are supposed, in great measure, compositions of other peoples; and what they take from others, they do it avowedly, and in the open sun.—In effect, their quality gives them a title to every thing that may be for their purpose, wherever they find it; and if they rob, they do not do it any otherwise than as the bee does, for the public service. Their occupation is not pillaging, but collecting contributions; and, if you ask them their authority, they will produce you the practice of their predecessors of all ages and nations."

Plagium, Plague.

PLAGIUM, in *Law*. See KIDNAPPING.

PLAGUE, PESTILENCE, or *Peſtilential Fever*, is a very acute, malignant, and contagious diſeaſe; being a putrid fever of the worſt kind, and ſeldom failing to prove mortal. Though it is generally defined a malignant fever, Diemerbrock thinks they ought to be diſtinguiſhed, ſince the fever is not the eſſence of the diſeaſe, but merely a ſymptom or effect of it. See MEDICINE, nº 221.

The plague, as is generally agreed, is never bred or propagated in Britain, but always imported from abroad, eſpecially from the Levant, Leſſer Aſia, Egypt, &c. where it is very common. Sydenham has remarked that it rarely infeſts this country oftener than once in 40 years, and happily we have been free of it for a much longer period.

Authors are not as yet agreed concerning the nature of this dreadful diſtemper. Some think that inſects are the cauſe of it, in the ſame way that they are the cauſe of blights, being brought in ſwarms from other climates by the wind, when they are taken into the lungs in reſpiration; the conſequence of which is, that they mix with the blood and juices, and attack and corrode the viſcera. Mr Boyle, on the other hand, thinks it originates from the effluvia or exhalations breathed into the atmoſphere from noxious minerals, to which may be added ſtagnant waters and putrid bodies of every kind.

Mr Gibbon thinks that the plague is derived from damp, hot, and ſtagnating air, and the putrefaction of animal ſubſtances, eſpecially locuſts. See *Gibbon's Roman Hiſtory*, 4to edit. vol. iv. p. 327—332, where there is alſo a very particular account of the plague which depopulated the earth in the time of the emperor Juſtinian.

The Mahometans believe that the plague proceeds from certain ſpirits, or goblins, armed with bows and arrows, ſent by God to puniſh men for their ſins; and that when the wounds are given by ſpectres of a black colour, they certainly prove fatal, but not ſo when the arrows are ſhot by thoſe that appear white. They therefore take no precaution to guard themſelves againſt it. The wiſer profeſſors of this religion, however, at preſent act otherwiſe; for we find a receipt recommended by Sidy Mohammed Zerroke, one of the moſt celebrated Marabouts, prefaced with theſe remarkable words: "The lives of us all are in the hands of God, when it is we muſt die. However, it hath pleaſed him to ſave many perſons from the plague, by taking every morning while the infection rages, one pill or two of the following compoſition; viz. of myrrh two parts, ſaffron one part, of aloes two parts, of ſyrup of myrtle berries, *q. ſ.*" But this remedy is confined to the more enlightened; for the bigotry of the lower ſort is ſo extreme as to make them deſpiſe all precautions which people of other nations uſe. Of this extreme and fooliſh prejudice Dr Chandler gives an intereſting account when ſpeaking of the plague at Smyrna. This learned author is of opinion that the diſeaſe ariſes from animalcules, which he ſuppoſes to be inviſible. See *Chandler's Travels in Aſia Minor*, p. 279. &c.

Plague.

It is a remarkable fact, that *plagues* are ſometimes partial, and that they only attack particular animals, or a particular deſcription of perſons, avoiding others altogether, or attacking them but ſlightly. Thus Fernelius informs us of a plague, or murrain, in 1514, which invaded only cats. Dionyſius Halicarnaſſeus mentions a plague which attacked none but maids; and that which raged in the time of Gentilis, killed ſcarcely any women, and very few but luſty men. Boterus mentions another plague, which aſſaulted none but the younger ſort; and we have inſtances of the ſame kind of a later ſtanding (A). Cardan ſpeaks of a plague at Baſil, with which the Switzers were infected, and the Italians, Germans, or French, exempted: and John Utenhovius takes notice of a dreadful one at Copenhagen, which, though it raged among the Danes, ſpared the Germans, Dutch, and Engliſh, who went with all freedom, and without the leaſt danger, to the houſes of the infected. During the plague which ravaged Syria in 1760, it was obſerved that people of the ſoundeſt conſtitutions were the moſt liable to it, and that the weak and delicate were either ſpared or eaſily cured. It was moſt fatal to the Moors; and, when it attacked them, it was generally incurable.

When the plague raged in Holland in 1636, a young girl was ſeized with it, had three carbuncles, and was removed to a garden, where her lover, who was betrothed to her, attended her as a nurſe, and ſlept with her as his wife. He remained uninfected, and ſhe recovered, and was married to him. The ſtory is related by Vinc. Fabricius in the *Miſc. Cur. Ann. II. Obſ.* 188.

Many methods have been adopted in different countries to prevent the importation of this dreadful ſcourge of the human race, and to ſtop the progreſs of infection after it has been imported. In England, mayors, bailiffs, head officers of corporations, and juſtices of peace, have power to tax inhabitants, houſes, and lands, &c. within their precincts, for the relief of perſons infected with the plague; and juſtices of the county may tax perſons within five miles round, on a pariſh's inability; the tax to be levied by diſtreſs and ſale of goods, or in default thereof by impriſonment. Infected perſons going abroad, after being commanded to keep houſe for avoiding farther infections, may be reſiſted by watchmen, &c. and puniſhed as vagrants, if they have no ſores upon them; and if they have infectious ſores on them it is felony. Juſtices of the peace, &c. are to appoint ſearchers, examiners, and buriers of the dead, in places infected, and adminiſter oaths to them for the performance of their duties, &c. *ſtat.* 1 *Jac.* 1. *cap.* 31. See QUARANTINE.

The commiſſion at Moſcow having, in the year 1770, invented a fumigation-powder, which, from ſeveral leſſer experiments, had proved efficacious in preventing the infection of the plague; in order more fully to aſcertain its virtue in that reſpect, it was determined,

(A) See the account of the *yellow fever* under the article PHILADELPHIA, where it appears that the diſeaſe was leſs fatal to ſome ſorts of perſons than to others.

termined, towards the end of the year, that ten malefactors under ſentence of death ſhould, without undergoing any other precautions than the fumigations, be confined three weeks in a lazaretto, be laid upon the beds, and dreſſed in the clothes, which had been uſed by perſons ſick, dying, and even dead, of the plague in the hoſpital. The experiment was accordingly tried, and none of the ten malefactors were then infected, or have been ſince ill. The fumigation powder is prepared as follows.

Powder of the firſt ſtrength.] Take leaves of juniper, juniper-berries pounded, ears of wheat, guaiacum wood pounded, of each ſix pounds; common ſaltpetre pounded, eight pounds; ſulphur pounded, ſix pounds; Smyrna tar, or myrrh, two pounds: mix all the above ingredients together, which will produce a pood of the powder of fumigation of the firſt ſtrength. [*N. B.* A pood is 40 pounds Ruſſian, which are equal to 35 pounds and a half or 36 pounds Engliſh avoirdupoiſe.]

Powder of the ſecond ſtrength.] Take ſouthernwood cut into ſmall pieces, four pounds; juniper berries pounded, three pounds; common ſaltpetre pounded, four pounds; ſulphur pounded, two pounds and a half; Smyrna tar, or myrrh, one pound and a half: mix the above together, which will produce half a pood of the powder of fumigation of the ſecond ſtrength.

Odoriferous powder.] Take the root called *kalmus* cut into ſmall pieces, three pounds; leaves of juniper cut into ſmall pieces four pounds; frankincenſe pounded groſsly, one pound; ſtorax pounded, and roſe flowers, half a pound; yellow amber pounded, one pound; common ſaltpetre pounded, one pouud and a half; ſulphur, a quarter of a pound: mix all the above together, which will produce nine pounds and three quarters of the odoriferous powder.

Remark on the powder of fumigation]. If guaiacum cannot be had, the cones of pines or firs may be uſed in its ſtead; likewiſe common tar of pines and firs may be uſed inſtead of the Smyrna tar, or myrrh, and mugwort may ſupply the place of ſouthernwood.

Thucydides, who was himſelf infected, lib. ii. gives us an account of a dreadful plague which happened at Athens about the year before Chriſt 430, while the Peloponneſians under the command of Archidamus waſted all her territory abroad; but of theſe two enemies the plague was by far the moſt dreadful and ſevere.

The moſt dreadful plague that ever raged at Rome was in the reign of Titus. A. D. 80. The emperor left no remedy unattempted to abate the malignity of the diſtemper, acting during its continuance like a father to his people. The ſame fatal diſeaſe raged in all the provinces of the Roman empire in the reign of M. Aurelius, A. D. 167, and was followed by a dreadful famine, by earthquakes, inundations, and other calamities. The Romans believed that Æſculapius ſometimes entered into a ſerpent, and cured the plague.

About the year 430 the plague viſited Britain, juſt after the Picts and Scots had made a formidable invaſion of the ſouthern part of the iſland. The plague raged with uncommon fury, and ſwept away moſt of thoſe whom the ſword and famine had ſpared, ſo that the living were ſcarcely ſufficient to bury the dead.

About the year 1348 the plague became almoſt general over Europe. A great many authors give an account of this plague, which is ſaid to have appeared firſt in the kingdom of Kathay in the year 1346, and to have proceeded gradually weſtward to Conſtantinople and Egypt. From Conſtantinople it paſſed into Greece, Italy, France, and Africa, and by degrees along the coaſts of the ocean into Britain and Ireland, and afterwards into Germany, Hungary, Poland, Denmark and the other northern kingdoms. According to Antoninus archbiſhop of Florence the diſtemper carried off 60,000 people in that city, among whom was the hiſtorian John Villani.

In the year 1656 the plague was brought from Sardinia to Naples, being introduced into the city by a tranſport with ſoldiers on board. It raged with exceſſive violence, carrying off in leſs than ſix months 400,000 of the inhabitants. The diſtemper was at firſt called by the phyſicians a malignant fever; but one of them affirming it to be peſtilential, the viceroy, who was apprehenſive leſt ſuch a report would occaſion all communication with Naples to be broke off, was offended with this declaration, and ordered him to be impriſoned. As a favour, however, he allowed him to return and die in his own houſe. By this proceeding of the viceroy, the diſtemper being neglected, made a moſt rapid and furious progreſs, and filled the whole city with conſternation. The ſtreets were crowded with confuſed proceſſions, which ſerved to ſpread the infection through all the quarters. The terror of the people increaſed their ſuperſtition; and it being reported that a certain nun had propheſied that the peſtilence would ceaſe upon building a hermitage for her ſiſter nuns upon the hill of St Martin's, the edifice was immediately begun with the moſt ardent zeal. Perſons of the higheſt quality ſtrove who ſhould perform the meaneſt offices; ſome loading themſelves with beams, and others carrying baſkets full of lime and nails, while perſons of all ranks ſtripped themſelves of their moſt valuable effects, which they threw into empty hogſheads placed in the ſtreets to receive the charitable contributions. Their violent agitation, however, and the increaſing heats, diffuſed the malady through the whole city, and the ſtreets and the ſtairs of the churches were filled with the dead; the number of whom, for ſome time of the month of July, amounted daily to 15,000.

The viceroy now uſed all poſſible precautions to abate the fury of the diſtemper, and to prevent its ſpreading to the provinces. The infection, however, deſolated the whole kingdom, excepting the provinces of Otranto and the Farther Calabria, and the cities of Gaeta, Sorrento, Paolo, and Belvedere. The general calamity was increaſed in Naples by malecontents, who inſinuated that the diſtemper had been deſignedly introduced by the Spaniards, and that there were people in diſguiſe who went through the city ſowing poiſoned duſt. This idle rumour enraged the populace, who began to inſult the Spaniſh ſoldiers, and threaten a ſedition; ſo that the viceroy, to pacify the mob, cauſed a criminal to be broke upon the wheel, under pretence that he was a diſperſer of the duſt. A violent and plentiful rain falling about the middle of Auguſt, the diſtember began to abate; and on the eighth of December the phyſicians made a ſolemn declaration that the city was entirely free from infection.

Of the dreadful plague which raged at London in the

Plague.

the year 1665, the reader will find an account in the article LONDON, N° 21. In 1720 the city of Marseilles was visited with this destructive disease, brought in a ship from the Levant; and in seven months, during which time it continued, it carried off not less than 60,000 people. This desolation is not yet obliterated from the minds of the inhabitants; some survivors remained alive but a few years ago to transmit a traditional account of it to after ages. There are two fine pictures, painted by Puget, representing some of the horrid scenes of that time. "They are (says Lady Craven) only too well executed. I saw several dying figures taking leave of their friends, and looking their last, anxious, kind, and wishful prayers on their sick infants, that made the tears flow down my cheeks. I was told the physicians and noblemen who were assisting the sick and dying, were all portraits: I can easily conceive it; for in some faces there is a look of reflection and concern which could only be drawn from the life." *Letters*, p. 34, 35. This fatal event has caused the laws of quarantine to be very strictly enforced in the lazaretto here, which is an extensive insulated building.

The ravages of this disease have been dreadful wherever it has made its appearance. On the first arrival of the Europeans at the island of Gran Canaria, it contained 14,000 fighting men, soon after which, two thirds of the whole inhabitants fell a sacrifice to the plague, which had doubtless been introduced by their new visitors. The destruction it has made in Turkey in Europe, and particularly in Constantinople, must be known to every reader; and its fatal effects have been particularly heightened there by that firm belief which prevails among the people of predestination, &c. as has been already mentioned. It is generally brought into European Turkey from Egypt; where it is very frequent, especially at *Grand CAIRO*. To give even a list of all the plagues which have desolated many flourishing countries, would extend this article beyond all bounds; and minutely to describe them all, would be impossible. For the plague at Smyrna, we refer to Chandler's Travels as above. Respecting that which raged in Syria in 1760, we refer to the Abbé Mariti's Travels through Cyprus, Syria, and Palestine, vol. i. p. 278—296. This plague was one of the most malignant and fatal that Syria ever experienced; for it scarcely made its appearance in any part of the body when it carried off the patient.

In addition to what the reader will find upon this subject in the article MEDICINE, and the observations which have now been offered, we beg leave to state the sentiments of Berthier on this subject, in his account of Bonaparte's expedition into Syria.

"At the time of our entry into Syria, (says he) all the towns were infected by the plague; a malady which ignorance and barbarity render so fatal in the east. Those who are affected by it give themselves up for dead; they are immediately abandoned by every body, and are left to die, when they might have been saved by medicine and attention.

"Citizen Degenettes, principal physician to the army, displayed a courage and character which entitle him to the national gratitude. When our soldiers were attacked by the least fever, it was supposed that they had caught the plague, and these maladies were confounded. The fever hospitals were abandoned by the officers of health and their attendants. Citizen Degenettes repaired in person to the hospitals, visited all the patients, felt the glandular swellings, dressed them, declared and maintained that the distemper was not the plague, but a malignant fever with glandular swellings, which might easily be cured by attention, and keeping the patient's mind easy."

The views of Degenettes in making this distinction were worthy of the highest commendation; but Dr Moseley maintains that this fever was actually the plague. The physician, however, carried his courage so far, as to make two incisions, and to inoculate the suppurated matter from one of these buboes above his breast, and under his armpits, but was not affected with the malady. He thus eased the minds of the soldiers, the first step to a cure; and, by his assiduity and constant attendance in the hospitals, a number of men attacked with the plague were cured. His example was followed by other officers of health. "There are, says Dr Moseley, annual or seasonal disorders, more or less severe, in all countries; but the plague, and other great depopulating epidemics, do not always obey the seasons of the year. Like comets, their course is eccentric. They have their revolutions; but from whence they come, or whether they go after they have made their revolution, no mortal can tell.

"Diseases originating in the atmosphere seize some, and pass by others; and act exclusively on bodies graduated to receive their impressions; otherwise whole nations would be destroyed. In some constitutions of the body the access is easy, in some difficult, and in others impossible.

"The air of confined places may be so vitiated as to be unfit for the purposes of the healthy existence of any person. Hence gaol, hospital, and ship fevers. But, as these distempers are the offspring of a local cause, that local cause, and not the distempered people, communicate the disease.

"The infection, were it not in the atmosphere, would be confined within very narrow limits; have a determinate sphere of action; and none but physicians and attendants on the sick would suffer; and these must suffer; and the cause and the effects would be palpable to our senses. Upon this ground, the precaution of quarantine would be rational. But who then would visit and attend the sick, or could live in hospitals, prisons, and lazarettos?"

The author is convinced from these reasonings, that the bubo and carbuncle, of which we hear so much in Turkey, and read so much in our own history of plagues, arise from heating food and improper treatment; that they contain no infection; and consequently that they are not the natural deposit of the morbific virus separated from the contagion.

Speaking of the plague, Mr Brown says, "the first symptoms are said to be thirst; 2. Cephalagia; 3. A stiff and uneasy sensation, with redness and tumour about the eyes; 4. Watering of the eyes; 5. White pustules on the tongue. Not uncommonly, all these have successively shown themselves, yet the patient has recovered; in which case, where suppuration has had place, the skin always remains discoloured, commonly of a purple hue. Many who have been bled in an early stage of the disorder, have recovered without any fatal symptoms;

ſymptoms; but whether from that or any other cauſe, does not appear certain."

Oil rubbed into the ſkin acts as a preventive, as well as a cure of the plague. When the operation is performed to prevent infection, it is ſucceſsfully performed with that view at Smyrna, as often as the plague makes its appearance in the city. As it is not done for the purpoſe of promoting perſpiration, it is not requiſite that it ſhould be performed with the ſame ſpeed as when for curing the diſorder; nor is it neceſſary to abſtain from fleſh, and to uſe ſoups; but it will be proper to uſe only fowls or veal for ſome days, without any ſeaſoning. It will in fine be neceſſary to guard againſt indigeſtible food, and ſuch liquors as might put in motion or inflame the maſs of the blood.

This intereſting diſcovery merits the attention of all medical men; for if olive oil has been found efficacious in curing or preſerving againſt one ſpecies of infection, it is not abſurd to ſuppoſe that the ſame or other kinds of oil might be productive of much benefit in other malignant infectious diſeaſes. We hope ſoon to hear of ſome trial being made with it in this country. Would it be of any ſervice in the yellow fever, ſo prevalent in the weſtern world?

PLAIN, or PLANE, in general, an appellation given to whatever is ſmooth and even, or ſimple, obvious, and eaſy to be underſtood; and, conſequently, ſtands oppoſed to rough, enriched, or laboured.

A plain figure, in geometry, is an uniform ſurface; from every point of whoſe perimeter right lines may be drawn to every other point in the ſame.

A plain angle is one contained under two lines, or ſurfaces, in contradiſtinction to a ſolid angle. See ANGLE under GEOMETRY.

The doctrine of plain triangles, as thoſe included under three right lines, is termed *plain trigonometry*. See the article TRIGONOMETRY.

PLAIN Chart. See the article CHART.

PLAIN-Sailing. See NAVIGATION.

PLAISE, the Engliſh name of a ſpecies of pleuronectes. See PLEURONECTES, ICHTHYOLOGY *Index*.

PLAN, in general, denotes the repreſentation of ſomething drawn on a plane; ſuch are maps, charts, ichnographies, &c. See MAP, CHART, &c.

The term *plan*, however, is particularly uſed for a draught of a building, ſuch as it appears, or is intended to appear, on the ground, ſhowing the extent, diviſion, and diſtribution of its area or ground-plot into apartments, rooms, paſſages, &c.

A geometrical plan is that wherein the ſolid and vacant parts are repreſented in their natural proportions.

The raiſed plan of a building is the ſame with what is otherwiſe called an *elevation* or *orthography*. See ORTHOGRAPHY.

A perſpective plan is that exhibited by degradations or diminutions, according to the rules of perſpective. See PERSPECTIVE.

To render plans intelligible, it is uſual to diſtinguiſh the maſſives with a black waſh; the projectures on the ground are drawn in full lines, and thoſe ſuppoſed over them in dotted lines. The augmentations or alterations to be made are diſtinguiſhed by a colour different from what is already built; and the tints of each plan made lighter as the ſtories are raiſed.

In large buildings it is uſual to have three ſeveral plans for the three firſt ſtories.

PLANCUS, FRANCIS, doctor of phyſic, was born at Amiens in 1696, and died on the 19th of September 1765, aged 69 years. He is the author of ſome works which have had conſiderable reputation. 1. A complete Syſtem of Surgery, in 2 vols in 12mo; a treatiſe much recommended by ſurgeons to their pupils. 2. A choice Library of Medicine, taken from periodical publications, both French and others: this curious collection, continued and completed by M. Goulin, makes 9 vols in 4to, or 18 vols in 12mo. 3. A Tranſlation of Vander Wiel's Obſervations on Medicine and Surgery, 1758, 2 vols in 12mo. Plancus was alſo the editor of various editions of works on medicine and ſurgery, which he enriched with notes.

PLANE, in *Geometry*, denotes a plain ſurface, or one that lies evenly between its bounding lines: and as a right line is the ſhorteſt extenſion from one point to another, ſo a plane ſurface is the ſhorteſt extenſion from one line to another.

In aſtronomy, conics, &c. the term *plane* is frequently uſed for an imaginary ſurface, ſuppoſed to cut and paſs through ſolid bodies; and on this foundation is the whole doctrine of conic ſections built. See ASTRONOMY, CONIC *Sections*, *&c.*

In mechanics, planes are either horizontal, that is, parallel to the horizon, or inclined thereto. See MECHANICS.

The determining how far any given plane deviates from an horizontal line, makes the whole buſineſs of levelling. See the article LEVELLING.

In optics, the planes of reflection and refraction are thoſe drawn through the incident and reflected or refracted rays. See OPTICS.

In perſpective we meet with the perſpective plane, which is ſuppoſed to be pellucid, and perpendicular to the horizon; the horizontal plane, ſuppoſed to paſs through the ſpectator's eye, parallel to the horizon; the geometrical plane, likewiſe parallel to the horizon, wherein the object to be repreſented is ſuppoſed to be placed, &c. See PERSPECTIVE.

The plane of projection in the ſtereographic projection of the ſphere, is that on which the projection is made, correſponding to the perſpective plane. See PROJECTION.

PLANE, in joinery, an edged tool or inſtrument for paring and ſhaving of wood ſmooth. It conſiſts of a piece of wood very ſmooth at bottom, as a ſtock or ſhaft; in the midſt of which is an aperture, through which a ſteel edge, or chiſſel, placed obliquely, paſſes; which, being very ſharp, takes off the inequalities of the wood along which it ſlides.

PLANE-Tree, in *Botany*. See PLATANUS.

PLANET, a celeſtial body, revolving round the ſun as a centre, and continually changing its poſition with reſpect to the fixed ſtars; whence the name *planet*, which is a Greek word, ſignifying "wanderer."

The planets are uſually diſtinguiſhed into primary and ſecondary. The primary ones, called by way of eminence *planets*, are thoſe which revolve round the ſun as a centre; and the ſecondary planets, more uſually called *ſatellites* or *moons*, are thoſe which revolve round a primary planet as a centre, and conſtantly attend it in its revolution round the ſun.

The primary planets are again diſtinguiſhed into ſuperior and inferior. The ſuperior planets are thoſe farther from the ſun than our earth; as Mars, Jupiter, Saturn, and the Georgium Sidus; and the inferior planets are thoſe nearer the ſun than our earth, as Venus and Mercury. For an account of the planets lately diſcovered, ſee VESTA.

That the planets are opaque bodies, like our earth, is thought probable for the following reaſons. 1. Since in Venus, Mercury, and Mars, only that part of the diſk illuminated by the ſun is found to ſhine; and again, Venus and Mercury, when between the earth and the ſun, appear like dark ſpots or maculæ on the ſun's diſk; it is evident, that Mars, Venus, and Mercury, are opaque bodies, illuminated with the borrowed light of the ſun. And the ſame appears of Jupiter, from its being void of light in that part to which the ſhadow of the ſatellites reaches, as well as in that part turned from the ſun; and that his ſatellites are opaque, and reflect the ſun's light, is abundantly ſhown. Again, ſince Saturn, with his ring and ſatellites, only yield a faint light, fainter conſiderably than that of the fixed ſtars, though theſe be vaſtly more remote, and than that of the reſt of the planets; it is paſt doubt that he too with his attendants are opaque bodies. 2. Since the ſun's light is not tranſmitted through Mercury and Venus, when placed againſt him, it is plain they are denſe opaque bodies; which is likewiſe evident of Jupiter, from his hiding the ſatellites in his ſhadow; and therefore, by analogy, the ſame may be concluded of Saturn. 3. From the variable ſpots of Venus, Mars, and Jupiter, it is evident theſe planets have a changeable atmoſphere; which changeable atmoſphere may, by a like argument, be inferred of the ſatellites of Jupiter; and therefore, by ſimilitude, the ſame may be concluded of the other planets. 4. In like manner, from the mountains obſerved in Venus, the ſame may be ſuppoſed in the other planets. 5. Since, then, Saturn, Jupiter, and the ſatellites of both, Mars, Venus, and Mercury, are opaque bodies ſhining with the ſun's borrowed light, are furniſhed with mountains, and encompaſſed with a changeable atmoſphere; they have, it is concluded, waters, ſeas, &c. as well as dry land, and are bodies like the moon, and therefore like the earth. And hence it ſeems alſo highly probable, that the other planets have their animal inhabitants as well as our earth.

PLANETARIUM, an aſtronomical machine, ſo called from its repreſenting the motions, orbits, &c. of the planets, agreeable to the Copernican ſyſtem. See ASTRONOMY.

PLANETARY, ſomething that relates to the planets. Hence we ſay, planetary worlds, planetary inhabitants, &c. See PLANET.

PLANETARY Syſtem, is the ſyſtem or aſſemblage of the planets, primary and ſecondary, moving in their reſpective orbits, round their common centre the ſun. See ASTRONOMY.

PLANETARY Days.—Among the ancients, the week was ſhared among the ſeven planets, each planet having its day. This we learn from Dion Caſſius and Plutarch, *Sympoſ.* l. 4. q. 7. Herodotus adds, that it was the Egyptians who firſt diſcovered what god, that is, what planet, preſides over each day; for that among this people the planets were directors. And hence it is, that in moſt European languages the days of the week are ſtill denominated from the planets; Sunday, Monday, &c. See WEEK.

PLANETARY Years, the periods of time in which the ſeveral planets make their revolutions round the ſun or earth.—As from the proper revolution of the ſun, the ſolar year takes its original; ſo from the proper revolutions of the reſt of the planets about the earth, ſo many ſorts of years do ariſe, viz. the Saturnian year, which is defined by 29 Egyptian years, 174 hours, 58 minutes, equivalent in a round number to 30 ſolar years. The Jovial year, containing 317 days, 14 hours, 59 minutes. —The Martial year, containing 321 days, 23 hours, 31 minutes. For Venus and Mercury, as their years, when judged of with regard to the earth, are almoſt equal to the ſolar year; they are more uſually eſtimated from the ſun, the true centre of their motions: in which caſe, the former is equal to 224 days, 16 hours, 40 minutes; the latter to 87 days, 23 hours, 14 minutes.

PLANIMETRY, that part of geometry which conſiders lines and plain figures, without conſidering their height or depth. See GEOMETRY.

PLANISPHERE, ſignifies a projection of the ſphere, and its various circles on a plane; in which ſenſe, maps, whereon are exhibited the meridians and other circles of the ſphere, are planiſpheres. See MAP.

PLANT is defined to be an organical body, deſtitute of ſenſe and ſpontaneous motion, adhering to another body in ſuch a manner as to draw from it its nouriſhment, and having a power of propagating itſelf by ſeeds.

The vegetation and economy of plants is one of thoſe ſubjects in which our knowledge is extremely circumſcribed. A total inattention to the ſtructure and economy of plants is the chief reaſon of the ſmall progreſs that has been made in the principles of vegetation, and of the inſtability and fluctuation of our theories concerning it; for which reaſon we ſhall give a ſhort deſcription of the ſtructure of plants, beginning with the ſeed, and tracing its progreſs and evolution to a ſtate of maturity.

1. *Of Seeds.*] The ſeeds of plants are of various figures and ſizes. Moſt of them are divided into two lobes; though ſome, as thoſe of the creſs-kind, have ſix; and others, as the grains of corn, are not divided, but entire.

But as the eſſential properties of all ſeeds are the ſame, when conſidered with regard to the principles of vegetation, our particular deſcriptions ſhall be limited to one ſeed, viz. the great garden-bean. Neither is the choice of this ſeed altogether arbitrary; for, after it begins to vegetate, its parts are more conſpicuous than many others, and conſequently better calculated for inveſtigation.

This ſeed is covered with two coats or membranes. The outer coat is extremely thin, and full of pores; but may be eaſily ſeparated from the inner one (which is much thicker), after the bean has been boiled, or lain a few days in the ſoil. At the thick end of the bean there is a ſmall hole viſible to the naked eye, immediately over the radicle or future root, that it may have a free paſſage into the ſoil (fig. 1. A). When theſe coats are taken off, the body of the ſeed appears, which is divided

Plate CCCCXX.

Plant.

ed into two ſmooth portions or lobes. The ſmoothneſs of the lobes is owing to a thin film or cuticle with which they are covered.

At the baſis of the bean is placed the radicle or future root (fig. 3. A). The trunk of the radicle, juſt as it enters into the body of the ſeed, divides into two capital branches, one of which is inſerted into each lobe, and ſends off ſmaller ones in all directions through the whole ſubſtance of the lobes (fig. 4. AA). Theſe ramifications become ſo extremely minute towards the edges of the lobes, that they require the fineſt glaſſes to render them viſible. To theſe ramifications Grew and Malpighi have given the name of *ſeminal root;* becauſe, by means of it, the radicle and plume, before they are expanded, derive their principal nouriſhment.

The plume, bud, or germ (fig. 3.), is incloſed in two ſmall correſponding cavities in each lobe. Its colour and conſiſtence is much the ſame with thoſe of the radicle, of which it is only a continuation, but having a quite contrary direction; for the radicle deſcends into the earth, and divides into a great number of ſmaller branches or filaments; but the plume aſcends into the open air, and unfolds itſelf into all the beautiful variety of ſtem, branches, leaves, flower, fruit, &c. The plume in corn ſhoots from the ſmaller end of the grain, and amongſt maltſters goes by the name of *acroſpire.*

The next thing to be taken notice of is the ſubſtance or parenchymatous part of the lobes. This is not a mere concreted juice, but is curiouſly organized, and conſiſts of a vaſt number of ſmall bladders reſembling thoſe in the pith of trees (fig. 5.).

Beſides the coats, cuticle, and parenchymatous parts, there is a ſubſtance perfectly diſtinct from theſe, diſtributed in different proportions through the radicle, plume, and lobes. This inner ſubſtance appears very plainly in a tranſverſe ſection of the radicle or plume. Towards the extremity of the radicle it is one entire trunk; but higher up it divides into three branches; the middle one runs directly up to the plume, and the other two paſs into the lobes on each ſide, and ſpread out into a great variety of ſmall branches through the whole body of the lobes (fig. 4.). This ſubſtance is very properly termed the *ſeminal root:* for when the ſeed is ſown, the moiſture is firſt abſorbed by the outer coats, which are everywhere furniſhed with ſap and air-veſſels; from theſe it is conveyed to the cuticle; from the cuticle it proceeds to the pulpy part of the lobes; when it has got thus far, it is taken up by the mouths of the ſmall branches of the ſeminal root, and paſſes from one branch into another, till it is all collected into the main trunk, which communicates both with the plume and radicle, the two principal involved organs of the future plant. After this the ſap or vegetable food runs in two oppoſite directions: part of it aſcends into the plume, and promotes the growth and expanſion of that organ; and part of it deſcends into the radicle, for nouriſhing and evolving the root and its various filaments. Thus the plume and radicle continue their progreſs in oppoſite directions till the plant arrives at maturity.

It is here worth remarking, that every plant is really poſſeſſed of two roots, both of which are contained in the ſeed. The plume and radicle, when the ſeed is firſt depoſited in the earth, derive their nouriſhment from the ſeminal root; but, afterwards, when the radicle begins to ſhoot out its filaments, and to abſorb ſome moiſture, not, however, in a ſufficient quantity to ſupply the exigencies of the plume, the two lobes, or main body of the ſeed, riſe along with the plume, aſſume the appearance of two leaves, reſembling the lobes of the ſeed in ſize and ſhape, but having no reſemblance to thoſe of the plume, for which reaſon they have got the name of *diſſimilar leaves.*

Theſe diſſimilar leaves defend the young plume from the injuries of the weather, and at the ſame time, by abſorbing dew, air, &c. aſſiſt the tender radicle in nouriſhing the plume, with which they have ſtill a connection by means of the ſeminal root above deſcribed. But when the radicle or ſecond root has deſcended deep enough into the earth, and has acquired a ſufficient number of filaments or branches for abſorbing as much aliment as is proper for the growth of the plume; then the ſeminal or diſſimilar leaves, their utility being entirely ſuperſeded, begin to decay and fall off.

Plate CCCCXX.

Fig. 1. A, the foramen or hole in the bean through which the radicle ſhoots into the ſoil.

Fig. 2. A tranſverſe ſection of the bean; the dots being the branches of the ſeminal root.

Fig. 3. A, the radicle. B, the plume or bud.

Fig. 4. A view of the ſeminal root branched out upon the lobes.

Fig. 5. A longitudinal ſection of one of the lobes of the bean a little magnified, to ſhow the ſmall bladders of which the pulpy or parenchymatous part is compoſed.

Figs. 6. 7. A, a tranſverſe ſection of the radicle. B, a tranſverſe ſection of the plume, ſhowing the organs or veſſels of the ſeminal root.

Fig. 8. The appearance of the radicle, plume, and ſeminal root, when a little further advanced in growth.

Having thus briefly deſcribed the ſeed, and traced its evolution into three principal organic parts, viz. the plume, radicle, and ſeminal leaves, we ſhall next take an anatomical view of the root, trunk, leaves, &c.

2. *Of the root.*] In examining the root of plants, the firſt thing that preſents itſelf is the ſkin, which is of various colours in different plants. Every root, after it has arrived at a certain age, has a double ſkin. The firſt is coeval with the other parts, and exiſts in the ſeed: but afterwards there is a ring ſent off from the bark, and forms a ſecond ſkin; *e. g.* in the root of the dandelion, towards the end of May, the original or outer ſkin appears ſhrivelled, and is eaſily ſeparated from the new one, which is freſher, and adheres more firmly to the bark. Perennial plants are ſupplied in this manner with a new ſkin every year; the outer one always falls off in the autumn and winter, and a new one is formed from the bark in the ſucceeding ſpring. The ſkin has numerous cells or veſſels, and is a continuation of the parenchymatous part of the radicle. However, it does not conſiſt ſolely of parenchyma; for the microſcope ſhows that there are many tubular ligneous veſſels interſperſed through it.

When the ſkin is removed, the true cortical ſubſtance or bark appears, which is alſo a continuation of the parenchymatous part of the radicle, but greatly augmented. The bark is of very different ſizes. In moſt trees it is exceeding thin in proportion to the wood and pith. On the other hand, in carrots, it is almoſt one-half of the ſemidiameter of the root; and, in dandelion, it is nearly twice as thick as the woody part.

The

Plant.

The bark is composed of two substances; the parenchyma or pulp, which is the principal part, and a few woody fibres. The parenchyma is exceedingly porous, and has a great resemblance to a sponge; for it shrivels considerably when dried, and dilates to its former dimensions when infused in water. These pores or vessels are not pervious, so as to communicate with each other; but consist of distinct little cells or bladders, scarcely visible without the assistance of the microscope. In all roots, these cells are constantly filled with a thin watery liquor. They are generally of a spherical figure; though in some roots, as the bugloss and dandelion, they are oblong. In many roots, as the horse radish, peony, asparagus, potato, &c. the parenchyma is of one uniform structure. But in others it is more diversified, and puts on the shape of rays, running from the centre towards the circumference of the bark. These rays sometimes run quite through the bark, as in lovage; and sometimes advance towards the middle of it, as in melilot and most of the leguminous and umbelliferous plants. These rays generally stand at an equal distance from each other in the same plant; but the distance varies greatly in different plants. Neither are they of equal sizes: in carrot they are exceedingly small, and scarcely discernible; in melilot and chervil, they are thicker. They are likewise more numerous in some plants than in others. Sometimes they are of the same thickness from one edge of the bark to the other; and some grow wider as they approach to the skin. The vessels with which these rays are amply furnished, are supposed to be air-vessels, because they are always found to be dry, and not so transparent as the vessels which evidently contain the sap.

In all roots there are ligneous vessels dispersed in different proportions through the parenchyma of the bark. These ligneous vessels run longitudinally through the bark in the form of small threads, which are tubular, as is evident from the rising of the sap in them when a root is cut transversely. These ligneous sap-vessels do not run in direct lines through the bark, but at small distances incline towards one another, in such a manner that they appear to the naked eye to be inosculated; but the microscope discovers them to be only contiguous, and braced together by the parenchyma. These braces or coarctations are very various both in size and number in different roots; but in all plants they are most numerous towards the inner edge of the bark. Neither are these vessels single tubes; but, like the nerves in animals, are bundles of 20 or 30 small contiguous cylindrical tubes, which uniformly run from the extremity of the root, without sending off any branches or suffering any change in their size or shape.

In some roots, as parsnep, especially in the ring next the inner extremity of the bark, these vessels contain a kind of lymph, which is sweeter than the sap contained in the bladders of the parenchyma. From this circumstance they have got the name of *lymph-ducts*.

These lymph-ducts sometimes yield a mucilaginous lymph, as in the comfrey; and sometimes a white milky glutinous lymph, as in the angelica, sonchus, burdock, scorzonera, dandelion, &c. The lymph-ducts are supposed to be the vessels from which the gums and balsams are secerned. The lymph of fennel, when exposed to the air, becomes a clear transparent balsam; and that of the scorzonera, dandelion, &c. condenses into a gum.

The situation of the vessels is various. In some plants they stand in a ring or circle at the inner edge of the bark, as in asparagus; in others, they appear in lines or rays, as in borage; in the parsnep, and several other plants, they are most conspicuous towards the outer edge of the bark; and in the dandelion, they are disposed in the form of concentric circles.

The wood of roots is that part which appears after the bark is taken off, and is firmer and less porous than the bark or pith. It consists of two distinct substances, viz. the pulpy or parenchymatous, and the ligneous. The wood is connected to the bark by large portions of the bark inserted into it. These insertions are mostly in the form of rays, tending to the centre of the pith, which are easily discernible by the eye in a transverse section of most roots. These insertions, like the bark, consist of many vessels, mostly of a round or oval figure.

The ligneous vessels are generally disposed in collateral rows running longitudinally through the root. Some of these contain air, and others sap. The *air-vessels* are so called, because they contain no liquor. These air-vessels are distinguished by being whiter than the others,

The pith is the centrical part of the root. Some roots have no pith, as the stramonium, nicotiana, &c.; others have little or none at the extremities of the roots, but have a considerable quantity of it near the top. The pith, like every other part of a plant, is derived from the seed; but in some it is more immediately derived from the bark: for the insertions of the bark running in betwixt the rays of the wood, meet in the centre, and constitute the pith. It is owing to this circumstance, that, among roots which have no pith in their lower parts, they are amply provided with it towards the top, as in columbine, lovage, &c.

The bladders of the pith are of very different sizes, and generally of a circular figure. Their position is more uniform than in the bark. Their sides are not mere films, but a composition of small fibres or threads; which gives the pith, when viewed with a microscope, the appearance of a piece of fine gauze or net-work.

We shall conclude the description of roots with observing, that their whole substance is nothing but a congeries of tubes and fibres, adapted by nature for the absorption of nourishment, and of course the extension and augmentation of their parts.

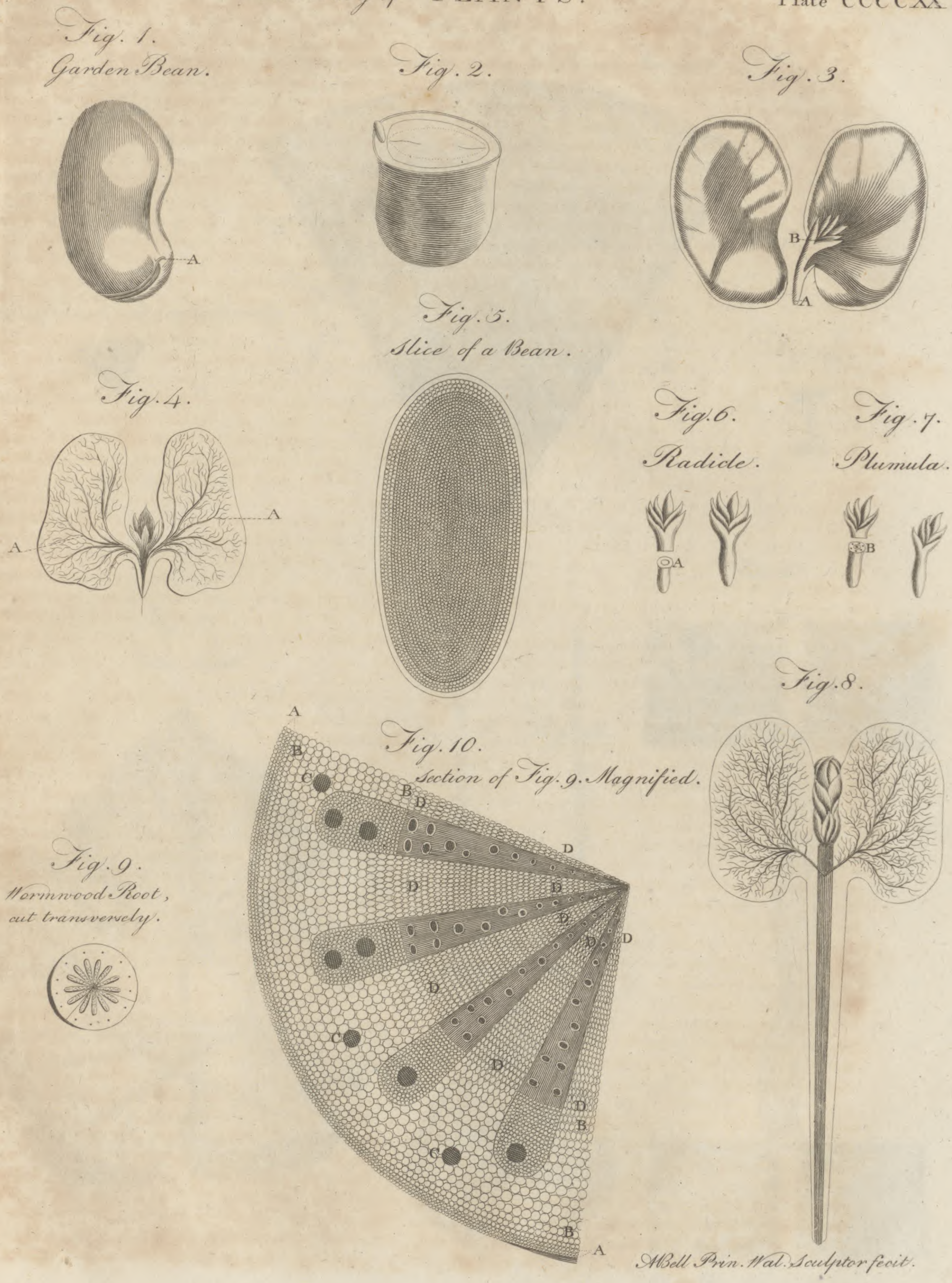
Fig. 9. A transverse section of the root of wormwood as it appears to the naked eye.

Fig. 10. A section of fig. 9. magnified. AA, the skin, with its vessels. BBBB, the bark. The round holes CCC, &c. are the lymph-ducts of the bark: All the other holes are little cells and sap-vessels. DDD, parenchymatous insertions from the bark, with the cells, &c. EEEE, the rays of the wood, in which the holes are the air-vessels. *N. B.* This root has no pith.

3. *Of the Trunk, Stalk, or Stem.*] In describing the trunks of plants, it is necessary to premise, that whatever is said with regard to them applies equally to the branches.

The trunk, like the root, consists of three parts, viz. the bark, wood, and pith. These parts, though substantially the same in the trunk as in the root, are in many cases very different in their texture and appearance. The

Anatomy of PLANTS. Plate CCCCXX.



A Bell Prin. Wal. Sculptor fecit.

Fig. 12.
Transverse Section of the Ash Branch Magnified.

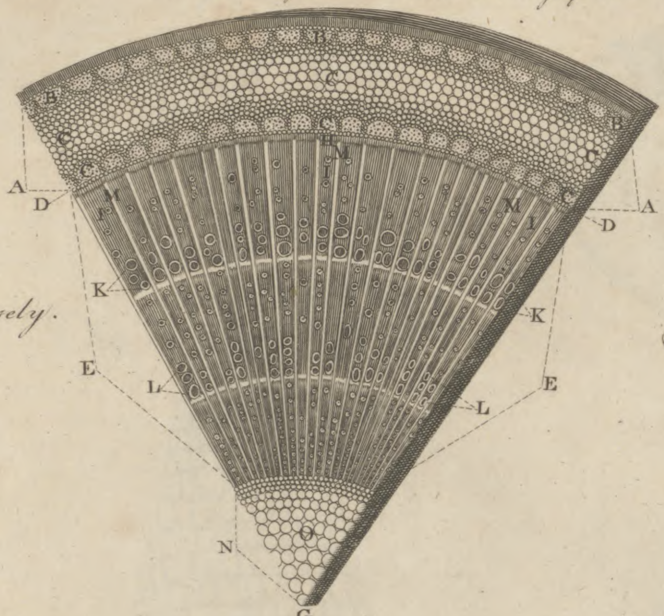


Fig. 11.
Ash Branch cut transversely.

Fig. 14.

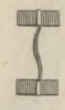


Fig. 15.

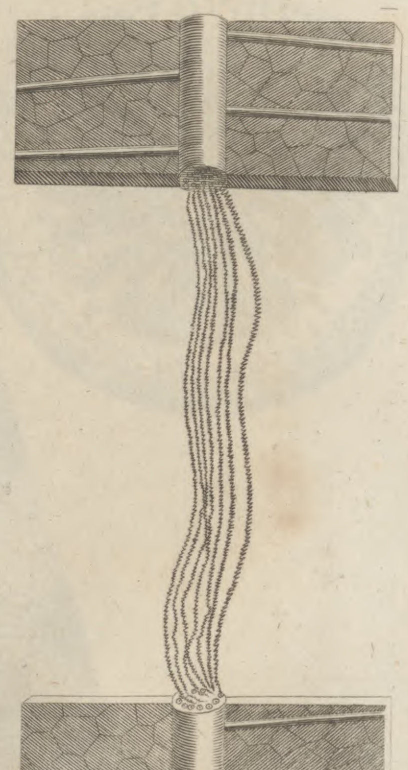
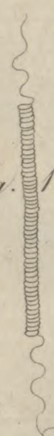


Fig. 13.
Vine Leaf.

Fig. 16. Fig. 16.



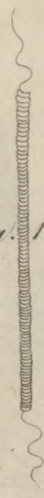


Fig. 17.
Tulip Root.

A Bell Prin. Wal. Sculptor fecit.

Fig. 18.
Pear cut transversely.

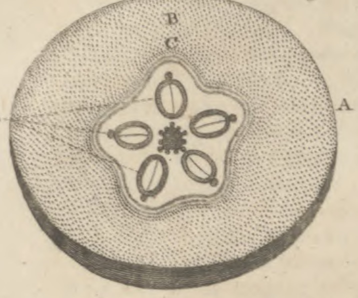


Fig. 19.
piece cut off fig. 18.

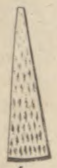


Fig. 21.
Pear cut Longitudinally.

Fig. 20.
Fig. 19. magnified.

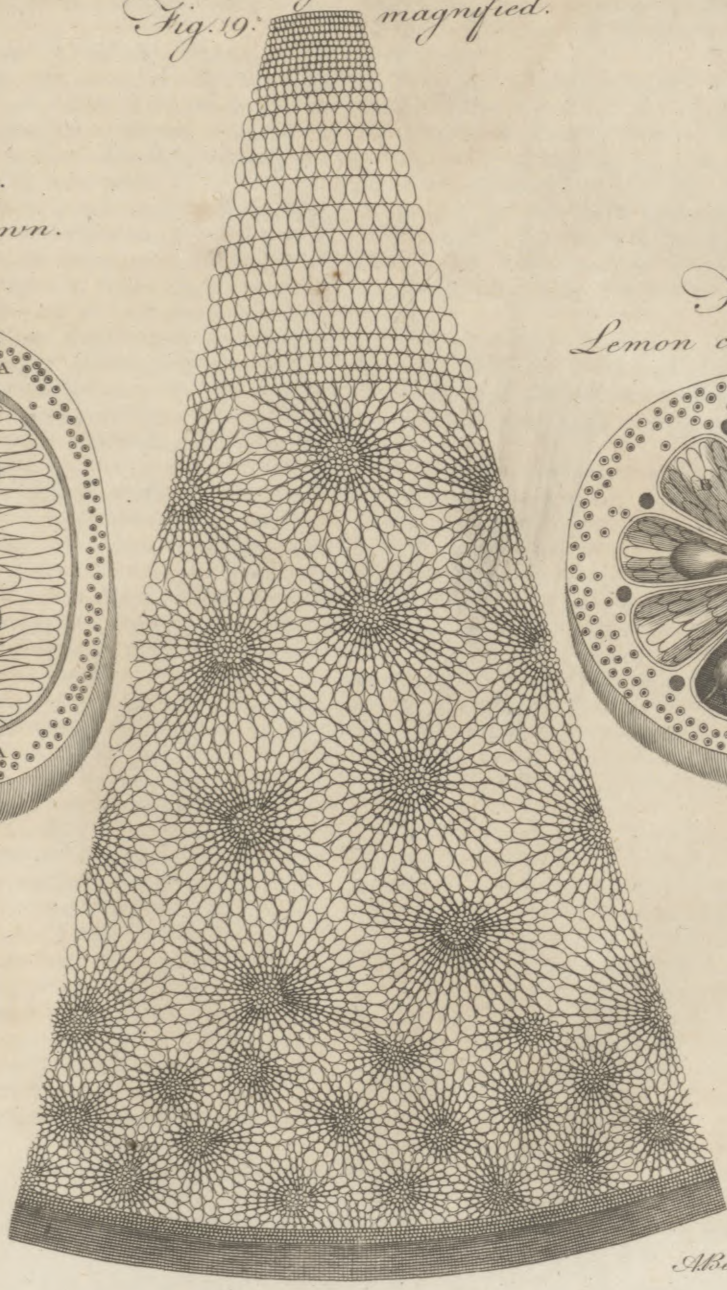


Fig. 22.
Lemon cut down.

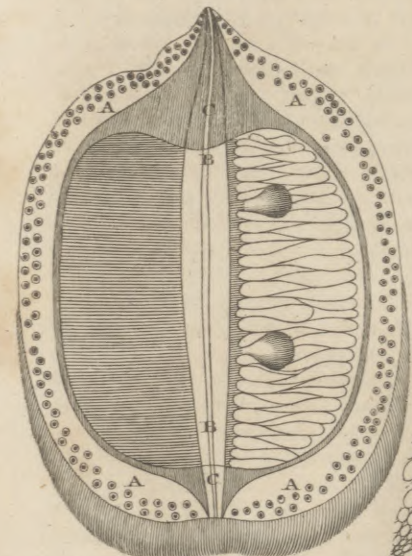
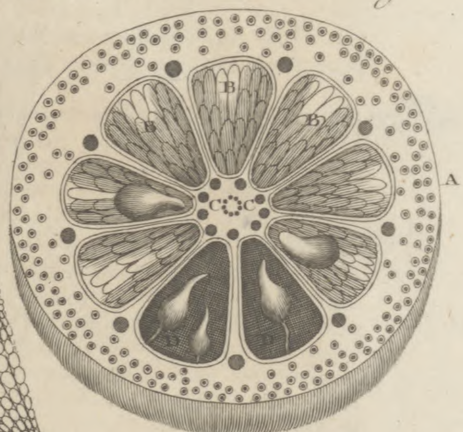


Fig. 23.
Lemon cut transversely.



A. Bell Prin. Wal. Sculptor fecit.

Plant.

The ſkin of the bark is compoſed of very minute bladders, interſperſed with longitudinal woody fibres, as in the nettle, thiſtle, and moſt herbs. The outſide of the ſkin is viſibly porous in ſome plants, particularly the cane.

The principal body of the bark is compoſed of pulp or parenchyma, and innumerable veſſels much larger than thoſe of the ſkin. The texture of the pulpy part, though the ſame ſubſtance with the parenchyma in roots, yet ſeldom appears in the form of rays running towards the pith; and when theſe rays do appear, they do not extend above half-way to the circumference. The veſſels of the bark are very differently ſituated, and deſtined for various purpoſes in different plants. For example, in the bark of the pine, the innermoſt are lymph-ducts, and exceedingly ſmall; the outermoſt are gum or reſiniferous veſſels, deſtined for the ſecretion of turpentine; and are ſo large as to be diſtinctly viſible to the naked eye.

The wood lies between the bark and pith, and conſiſts of two parts, viz. a parenchymatous and a ligneous. In all trees, the parenchymatous part of the wood, though much diverſified as to ſize and conſiſtence, is uniformly diſpoſed in diametrical rays, or inſertions running betwixt ſimilar rays of the ligneous part.

The true wood is nothing but a congeries of old dried lymph-ducts. Between the bark and the wood a new ring of theſe ducts is formed every year, which gradually loſes its ſoftneſs as the cold ſeaſon approaches, and towards the middle of winter is condenſed into a ſolid ring of wood. Theſe annual rings, which are diſtinctly viſible in moſt trees when cut through, ſerve as natural marks to diſtinguiſh their age (fig. 11. 12.). The rings of one year are ſometimes larger, ſometimes leſs, than thoſe of another, probably owing to the favourableneſs or unfavourableneſs of the ſeaſon.

The pith, though of a different texture, is exactly of the ſame ſubſtance with the parenchyma of the bark, and the inſertions of the wood. The quantity of pith is various in different plants. Inſtead of being increaſed every year like the wood, it is annually diminiſhed, its veſſels drying up, and aſſuming the appearance and ſtructure of wood; inſomuch that in old trees there is ſcarce ſuch a thing as pith to be diſcerned.

A ring of ſap-veſſels is uſually placed at the outer edge of the pith, next the wood. In the pine, fig, and walnut, they are very large. The parenchyma of the pith is compoſed of ſmall cells or bladders, of the ſame kind with thoſe of the bark, only of a larger ſize. The general figure of theſe bladders is circular; though in ſome plants, as the thiſtle and borage, they are angular. Though the pith is originally one connected chain of bladders, yet as the plant grows old they ſhrivel, and open in different directions. In the walnut, after a certain age, it appears in the form of a regular tranſverſe hollow diviſion. In ſome plants it is altogether wanting; in others, as the ſonchus, nettle, &c. there is only a tranſverſe partition of it at every joint. Many other varieties might be mentioned; but theſe muſt be left to the obſervation of the reader.

Fig. 11. A tranſverſe ſection of a branch of aſh, as it appears to the eye.

Fig. 12. The ſame ſection magnified. AA, the bark. BBB, an arched ring of ſap-veſſels next the ſkin. CCC, the parenchyma of the bark with its cells, and another arched ring of ſap-veſſels. DD, a circular line of lymph-ducts immediately below the above arched ring. EE, the wood. F, the firſt year's growth. G, the ſecond. H, the third year's growth. II, the true wood. KK, the great air-veſſels. LL, the leſſer ones. MMM, the parenchymatous inſertions of the bark repreſented by the white rays. NO, the pith, with its bladders or cells.

4. *Of the Leaves.*] The leaves of plants conſiſt of the ſame ſubſtance with that of the trunk. They are full of nerves or woody portions, running in all directions, and branching out into innumerable ſmall threads, interwoven with the parenchyma like fine lace or gauze.

The ſkin of the leaf, like that of an animal, is full of pores, which both ſerve for perſpiration and for the abſorption of dews, air, &c. Theſe pores or orifices differ both in ſhape and magnitude in different plants, which is the cauſe of that variety of texture or grain peculiar to every plant.

The pulpy or parenchymatous part conſiſts of very minute fibres, wound up into ſmall cells or bladders. Theſe cells are of various ſizes in the ſame leaf.

All leaves, of whatever figure, have a marginal fibre, by which all the reſt are bounded. The particular ſhape of this fibre determines the figure of the leaf.

The veſſels of leaves have the appearance of inoſculating; but, when examined by the microſcope, they are found only to be interwoven or laid along each other.

What are called *air-veſſels*, or thoſe which carry no ſap, are viſible even to the naked eye in ſome leaves. When a leaf is ſlowly broken, they appear like ſmall woolly fibres, connected to both ends of the broken piece.

Plate CCCCXXI.

Fig. 13. The appearance of the air-veſſels to the eye, in a vine-leaf drawn gently aſunder.

Fig. 14. A ſmall piece cut off that leaf.

Fig. 15. The ſame piece magnified, in which the veſſels have the appearance of a ſcrew.

Fig. 16. The appearance of theſe veſſels as they exiſt in the leaf before they are ſtretched out.

5. *Of the Flower.*] It is needleſs here to mention any thing of the texture, or of the veſſels, &c. of flowers, as they are pretty ſimilar to thoſe of the leaf. It would be foreign to our preſent purpoſe to take any notice of the characters and diſtinctions of flowers. Theſe belong to the ſcience of BOTANY, to which the reader is referred.

There is one curious fact, however, which muſt not be omitted, viz. That every flower is perfectly formed in its parts many months before it appears outwardly; that is, the flowers which appear this year are not properly ſpeaking the flowers of this year, but of the laſt. For example, mezereon generally flowers in January; but theſe flowers were completely formed in the month of Auguſt preceding. Of this fact any one may ſatisfy himſelf by ſeparating the coats of a tulip root about the beginning of September; and he will find that the two innermoſt form a kind of cell, in the centre of which ſtands the young flower, which is not to make its appearance till the following April or May. Fig. 18. exhibits a view of the tulip-root when diſſected in September, with the young flower towards the bottom.

6. *Of the Fruit.*] In deſcribing the ſtructure of fruits, a

a few examples ſhall be taken from ſuch as are moſt generally known.

A *pear*, beſides the ſkin, which is a production of the ſkin of the bark, conſiſts of a double parenchyma or pulp, ſap, and air-veſſels, calculary and acetary.

The outer parenchyma is the ſame ſubſtance continued from the bark, only its bladders are larger and more ſucculent.

It is everywhere interſperſed with ſmall globules or grains, and the bladders reſpect theſe grains as a kind of centres, every grain being the centre of a number of bladders. The ſap and air-veſſels in this pulp are extremely ſmall.

Next the core is the inner pulp or parenchyma, which conſiſts of bladders of the ſame kind with the outer, only larger and more oblong, correſponding to thoſe of the pulp, from which it ſeems to be derived. This inner pulp is much ſourer than the other, and has none of the ſmall grains interſperſed through it; and hence it has got the name of *acetary*.

Between the acetary and outer pulp, the globules or grains begin to grow larger, and gradually unite into a hard ſtony body, eſpecially towards the corculum or ſtool of the fruit; and from this circumſtance it has been called the *calculary*.

Theſe grains are not derived from any of the organical parts of the tree; but ſeem rather to be a kind of concretions precipitated from the ſap, ſimilar to the precipitation from wine, urine, and other liquors.

The core is a roundiſh cavity in the centre of the pear, lined with a hard woody membrane, in which the ſeed is incloſed. At the bottom of the core there is a ſmall duct or canal, which runs up to the top of the pear; this canal allows the air to get into the core, for the purpoſe of drying and ripening the ſeeds.

Fig. 18. a tranſverſe ſection of a pear, as it appears to the naked eye. A, the ſkin, and a ring of ſap-veſſels. B, the outer parenchyma, or pulp, with its veſſels, and ligneous fibres interſperſed. C, the inner parenchyma, or acetary, with its veſſels, which are larger than the outer one. D, the core and ſeeds.

Fig. 19. a piece cut off, fig. 19.

Fig. 20. is fig. 19. magnified. A A A, the ſmall grains or globules, with the veſſels radiated from them.

Fig. 21. a longitudinal ſection of the pear, ſhowing a different view of the ſame parts with thoſe of fig. 18. A the channel, or duct, which runs from the top of the pear to the bottom of the core.

In a *lemon*, the parenchyma appears in three different forms. The parenchyma of the rind is of a coarſe texture, being compoſed of thick fibres, woven into large bladders. Thoſe neareſt the ſurface contain the eſſential oil of the fruit, which burſts into a flame when the ſkin is ſqueezed over a candle. From this outmoſt parenchyma nine or ten inſertions or lamellæ are produced, which run between as many portions of the pulp, and unite into one body in the centre of the fruit, which correſponds to the pith in trunks or roots. At the bottom and top of the lemon, this pith evidently joins with the rind, without the intervention of any lamellæ. This circumſtance ſhows, that the pith and bark are actually connected in the trunk and roots of plants, though it is difficult to demonſtrate the connection, on account of the cloſeneſs of their texture, and the minuteneſs of their fibres. Many veſſels are diſperſed through the whole of this parenchyma; but the largeſt ones ſtand on the inner edge of the rind, and the outer edge of the pith, juſt at the two extremities of each lamella.

The ſecond kind of parenchyma is placed between the rind and the pith; is divided into diſtinct bodies by the lamellæ; and each of theſe bodies forms a large bag.

Theſe bags contain a third parenchyma, which is a cluſter of ſmaller bags, diſtinct and unconnected with each other, having a ſmall ſtalk by which they are fixed to the large bag. Within each of theſe ſmall bags are many hundreds of bladders, compoſed of extremely minute fibres. Theſe bladders contain the acid juice of the lemon.

Fig. 22. a longitudinal ſection of a lemon. A A, the rind with the veſſels which contain the eſſential oil. B B, the ſubſtance correſponding to the pith, formed by the union of the lamellæ or inſertions. C C, its continuation and connection with the rind, independent of the inſertions.

Fig. 23. a tranſverſe ſection of the lemon. B B B, &c. the nine pulpy bags, or ſecond parenchyma, placed between the rind and the pith; and the cluſter of ſmall bags, which contain the acid juice, incloſed in the large ones. C C, the large veſſels that ſurround the pith. D D, two of the large bags laid open, ſhowing the ſeeds, and their connection with the lamellæ or membranes which form the large bags.

Of the Perſpiration of PLANTS, *and the quantity of moiſture daily imbibed by them.*—Theſe curious particulars have been determined with great accuracy by Dr Hales. The method he took to accompliſh his purpoſe was as follows.—In the month of July, commonly the warmeſt ſeaſon of the year, he took a large ſun-flower three feet and an half high, which had been purpoſely planted in a flower-pot when young. He covered the pot with thin milled lead, leaving only a ſmall hole to preſerve a communication with the external air, and another by which he might occaſionally ſupply the plant with water. Into the former he inſerted a glaſs tube nine inches long, and another ſhorter tube into the hole by which he poured in the water; and the latter was kept cloſe ſtopped with a cork, except when there was occaſion to uſe it. The holes in the bottom of the pot were alſo ſtopped up with corks, and all the crevices ſhut with cement.—Things being thus prepared, the pot and plant were weighed for 15 ſeveral days; after which the plant was cut off cloſe to the leaden plate, and the ſtump well covered with cement. By weighing, he found that there perſpired through the unglazed porous pot two ounces every 12 hours; which being allowed for in the daily weighing of the plant and pot, the greateſt perſpiration, in a warm day, was found to be one pound 14 ounces; the middle rate of perſpiration, one pound four ounces; the perſpiration of a dry warm night, without any ſenſible dew, was about three ounces; but when there was any ſenſible though ſmall dew, the perſpiration was nothing; and when there was a large dew, or ſome little rain in the night, the plant and pot was increaſed in weight two or three ounces.

In order to know what quantity was perſpired from a ſquare inch of ſurface, our author cut off all the leaves of the plant, and laid them in five ſeveral parcels, according to their ſeveral ſizes; and then meaſured the ſurface of a leaf of each parcel, by laying over it a large lattice

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lattice made with threads, in which each of the little squares was $\frac{1}{4}$ of an inch; by numbering of which, he had the surface of the leaves in square inches; which, multiplied by the number of leaves in the corresponding parcels, gave the area of all the leaves. By this method he found the surface of the whole plant above ground to be 5616 square inches, or 39 square feet. He dug up another sun-flower of nearly the same size, which had eight main roots, reaching 15 inches deep and sidewise, from the stem. It had besides a very thick bush of lateral roots from the eight main roots, extending every way in a hemisphere about nine inches from the stem and main roots. In order to estimate the length of all the roots, he took one of the main roots with its laterals, and measured and weighed them; and then weighed the other seven with their laterals; by which means he found the sum of all their lengths to be 1448 feet. Supposing then the periphery of these roots at a medium to be 0.131 of an inch, then their surface will be 2276 square inches, or 15.8 square feet; that is, equal to 0.4 of the surface of the plant above ground. From calculations drawn from these observations, it appears, that a square inch of the upper surface of this plant perspires $\frac{1}{165}$ part of an inch in a day and a night; and that a square inch of the surface underground imbibed $\frac{1}{67}$ of an inch in the same time.

The quantity perspired by different plants, however, is by no means equal. A vine-leaf perspires only $\frac{1}{191}$ of an inch in 12 hours; a cabbage perspires $\frac{1}{80}$ of an inch in the same time; an apple-tree $\frac{1}{102}$ in 12 hours; and a lemon $\frac{1}{248}$ in 12 hours.

Of the circulation of the Sap in PLANTS.—Concerning this there have been great disputes; some maintaining, that the vegetable sap has a circulation analogous to the blood of animals; while others affirm, that it only ascends in the day-time, and descends again in the night. In favour of the doctrine of circulation it has been urged, that upon making a transverse incision into the trunk of a tree, the juice which runs out proceeds in greater quantity from the upper than the lower part; and the swelling in the upper lip is also much greater than in the lower. It appears, however, that when two similar incisions are made, one near the top and the other near the root, the latter expends much more sap than the former. Hence it is concluded, that the juice ascends by one set of vessels and descends by another. But, in order to show this clearly, it would be necessary first to prove that there is in plants, as in animals, some kind of centre from which the circulation begins, and to which it returns; but no such centre has been discovered by any naturalist; neither is there the least provision apparently made by nature whereby the sap might be prevented from descending in the very same vessels through which it ascends. In the lacteal vessels of animals, which we may suppose to be analogous to the roots of vegetables, there are valves which effectually prevent the chyle when once absorbed from returning into the intestines; but no such thing is observed in the vessels of vegetables; whence it must be very probable, that when the propelling force ceases, the juice descends by the very same vessels through which it ascended.—This matter, however, has been cleared up almost as well as the nature of the subject will admit of by the experiments of Dr Hales †. These experiments are so numerous, that for a particular account of them we must refer to the work itself; however, his reasoning against the circulation of the sap will be sufficiently intelligible without them. "We see (says he), in many of the foregoing experiments, what quantities of moisture trees daily imbibe and perspire: now the celerity of the sap must be very great, if that quantity of moisture must, most of it, ascend to the top of the tree, then descend, and ascend again, before it is carried off by perspiration.

† *Vegetable Statics*, vol. i. p. 142.

"The defect of a circulation in vegetables seems in some measure to be supplied by the much greater quantity of liquor, which the vegetable takes in, than the animal, whereby its motion is accelerated; for we find the sun-flower, bulk for bulk, imbibes and perspires 17 times more fresh liquor than a man, every 24 hours.

"Besides, Nature's great aim in vegetables being only that the vegetable life be carried on and maintained, there was no occasion to give its sap the rapid motion which was necessary for the blood of animals.

"In animals, it is the heart which sets the blood in motion, and makes it continually circulate; but in vegetables we can discover no other cause of the sap's motion but the strong attraction of the capillary sap-vessels, assisted by the brisk undulations and vibrations caused by the sun's warmth, whereby the sap is carried up to the top of the tallest trees, and is there perspired off through the leaves: but when the surface of the tree is greatly diminished by the loss of its leaves, then also the perspiration and motion of the sap is proportionably diminished, as is plain from many of the foregoing experiments: so that the ascending velocity of the sap is principally accelerated by the plentiful perspiration of the leaves, thereby making room for the fine capillary vessels to exert their vastly attracting power, which perspiration is effected by the brisk rarefying vibrations of warmth; a power that does not seem to be any ways well adapted to make the sap descend from the tops of vegetables by different vessels to the root.

"If the sap circulated, it must needs have been seen descending from the upper part of large gashes cut in branches set in water, and with columns of water pressing on their bottoms in long glass tubes. In both which cases it is certain that great quantities of water passed through the stem, so that it must needs have been seen descending, if the return of the sap downwards were by trusion or pulsion, whereby the blood in animals is returned through the veins to the heart; and that pulsion if there were any, must necessarily be exerted with prodigious force, to be able to drive the sap through the finer capillaries. So that, if there be a return of the sap downwards, it must be by attraction, and that a very powerful one, as we may see by many of these experiments. But it is hard to conceive what and where that power is which can be equivalent to that provision nature has made for the ascent of the sap in consequence of the great perspiration of the leaves.

"The instances of the jessamine-tree, and of the passion-tree, have been looked upon as strong proofs of the circulation of the sap, because their branches, which were far below the inoculated bud, were gilded: but we have many visible proofs in the vine, and other bleeding trees, of the sap's receding back, and pushing forwards alternately, at different times of the day and night. And there is great reason to think that the sap of all other trees, has such an alternate, receding, and progressive motion, occasioned by the alternacies of day and night, warm and cool, moist and dry.

 "For

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"For the ſap in all vegetables does probably recede in ſome meaſure from the tops of the branches, as the ſun leaves them; becauſe its rarefying power then ceaſing, the greatly rarefied ſap, and air mixed with it, will condenſe, and take up leſs room than they did, and the dew and rain will then be ſtrongly imbibed by the leaves; whereby the body and branches of the vegetable which have been much exhauſted by the great evaporation of the day, may at night imbibe ſap and dew from the leaves; for by ſeveral experiments, plants were found to increaſe conſiderably in weight, in dewy and moiſt nights. And by other experiments on the vine, it was found that the trunk and branches of vines were always in an imbibing ſtate, cauſed by the great perſpiration of the leaves, except in the bleeding ſeaſon; but when at night that perſpiring power ceaſes, then the contrary imbibing power will prevail, and draw the ſap and dew from the leaves, as well as moiſture from the roots.

"And we have a farther proof of this by fixing mercurial gages to the ſtems of ſeveral trees which do not bleed, whereby it is found that they are always in a ſtrongly imbibing ſtate, by drawing up the mercury ſeveral inches: whence it is eaſy to conceive, how ſome of the particles of the gilded bud in the inoculated jeſſamine may be abſorbed by it, and thereby communicate their gilding miaſma to the ſap of other branches; eſpecially when, ſome months after the inoculation, the ſtock of the inoculated jeſſamine is cut off a little above the bud; whereby the ſtock, which was the counteracting part to the ſtem, being taken away, the ſtem attracts more vigorouſly from the bud.

"Another argument for the circulation of the ſap is, that ſome ſorts of the graffs will infect and canker the ſtocks they are grafted on: but by mercurial gages fixed to freſh-cut ſtems of trees, it is evident that thoſe ſtems were in a ſtrongly imbibing ſtate; and conſeqently the cankered ſtocks might very likely draw ſap from the graff, as well as the graff alternately from the ſtock; juſt in the ſame manner as leaves and branches do from each other, in the viciſſitudes of day and night. And this imbibing power of the ſtock is ſo great, where only ſome of the branches of a tree are grafted, that the remaining branches of the ſtock will, by their ſtrong attraction, ſtarve thoſe graffs; for which reaſon it is uſual to cut off the greateſt part of the branches of the ſtock, leaving only a few ſmall ones to draw up the ſap.

"The inſtance of the ilex grafted upon the Engliſh oak, ſeems to afford a very conſiderable argument againſt a circulation. For, if there were a free uniform circulation of the ſap through the oak and ilex, why ſhould the leaves of the oak fall in winter, and not thoſe of the ilex?

"Another argument againſt an uniform circulation of the ſap in trees, as in animals, may be drawn from an experiment, where it was found by the three mercurial gages fixed to the ſame vine, that while ſome of its branches changed their ſtate of protruding ſap into a ſtate of imbibing, others continued protruding ſap; one nine, and the other thirteen days longer."

To this reaſoning of Dr Hales we ſhall ſubjoin an experiment made by Mr Muſtel of the Academy of Sciences at Rouen, which ſeems deciſive againſt the doctrine of circulation. His account of it is as follows.—"On the 12th of January I placed ſeveral ſhrubs in pots againſt the windows of my hot-houſe, ſome within the houſe and others without it. Through holes made for this purpoſe in the panes of glaſs, I paſſed a branch of each of the ſhrubs, ſo that thoſe in the inſide had a branch without, and thoſe on the outſide one within; after this, I took care that the holes ſhould be exactly cloſed and luted. This inverſe experiment, I thought, if followed cloſely, could not fail affording ſufficient points of compariſon, to trace out the differences, by the obſervation of the effects.

"The 20th of January, a week after this diſpoſition, all the branches that were in the hot-houſe began to diſcloſe their buds. In the beginning of February there appeared leaves; and towards the end of it, ſhoots of a conſiderable length, which preſented the young flowers. A dwarf apple-tree, and ſeveral roſe-trees, being ſubmitted to the ſame experiment, ſhowed the ſame appearance then as they commonly put on in May; in ſhort, all the branches which were within the hot-houſe, and conſequently kept in the warm air, were green at the end of February, and had their ſhoots in great forwardneſs. Very different were thoſe parts of the ſame tree which were without and expoſed to the cold. None of theſe gave the leaſt ſign of vegetation; and the froſt, which was intenſe at that time, broke a roſe-pot placed on the outſide, and killed ſome of the branches of that very tree which, on the inſide, was every day putting forth more and more ſhoots, leaves, and buds, ſo that it was in full vegetation on one ſide, whilſt frozen on the other.

"The continuance of the froſt occaſioned no change in any of the internal branches. They all continued in a very briſk and verdant ſtate, as if they did not belong to the tree which, on the outſide, appeared in the ſtate of the greateſt ſuffering. On the 15th of March, notwithſtanding the ſeverity of the ſeaſon, all was in full bloom. The apple-tree had its root, its ſtem, and part of its branches, in the hot-houſe. Theſe branches were covered with leaves and flowers; but the branches of the ſame tree, which were carried on the outſide, and expoſed to the cold air, did not in the leaſt partake of the activity of the reſt, but were abſolutely in the ſame ſtate which all trees are in during winter. A roſe-tree, in the ſame poſition, ſhowed long ſhoots with leaves and buds; it had even ſhot a vigorous branch upon its ſtalk; whilſt a branch which paſſed through to the outſide had not begun to produce any thing, but was in the ſame ſtate with other roſe-trees left in the ground. This branch is four lines in diameter, and 18 inches high.

"The roſe-tree on the outſide was in the ſame ſtate; but one of its branches drawn through to the inſide of the hot-houſe was covered with leaves and roſe-buds. It was not without aſtoniſhment that I ſaw this branch ſhoot as briſkly as the roſe-tree which was in the hot-houſe, whoſe roots and ſtalk, expoſed as they were to the warm air, ought, it ſhould ſeem, to have made it get forwarder than a branch belonging to a tree, whoſe roots, trunk, and all its other branches, were at the very time froſt-nipped. Notwithſtanding this, the branch did not ſeem affected by the ſtate of its trunk; but the action of the heat upon it produced the ſame effect as if the whole tree had been in the hot-houſe."

Of the Perpendicularity of PLANTS.—This is a curious phenomenon in natural hiſtory, which was firſt obſerved by M. Dodart, and publiſhed in an eſſay on the affectation

Memoires de l'Acad. Royal des Sciences. an. 1708.

affectation of perpendicularity obſerved in the ſtems or ſtalks of all plants, in the roots of many, and even in their branches, as much as poſſible. Though almoſt all plants riſe a little crooked, yet the ſtems ſhoot up perpendicularly, and the roots ſink down perpendicularly: even thoſe, which by the declivity of the ſoil come out inclined, or thoſe which are diverted out of the perpendicular by any violent means, again redreſs and ſtraighten themſelves and recover their perpendicularity, by making a ſecond and contrary bend or elbow without rectifying the firſt. We commonly look upon this affectation without any ſurpriſe; but the naturaliſt who knows what a plant is, and how it is formed, finds it a ſubject of aſtoniſhment.

Each ſeed we know contains in it a little plant, already formed, and needing nothing but to be unfolded; the little plant has its root; and the pulp, which is uſually ſeparated into two lobes, is the foundation of the firſt food it draws by its root when it begins to germinate. If a ſeed in the earth therefore be diſpoſed ſo as that the root of the little plant be turned downwards, and the ſtem upwards, and even perpendicularly upwards, it is eaſy to conceive that the little plant coming to unfold itſelf, its ſtalk and root need only follow the direction they have to grow perpendicularly. But we know that the ſeeds of plants, whether ſown of themſelves or by man, fall in the ground at random; and among the great variety of ſituations with regard to the ſtalk of their plant, the perpendicular one upwards is but one. In all the reſt, therefore, it is neceſſary that the ſtalk rectify itſelf, ſo as to get out of the ground: but what force effects this change, which is unqueſtionably a violent action? Does the ſtalk find a leſs load of earth above it, and therefore go naturally that way where it finds the leaſt obſtacle? Were this ſo, the little root, when it happens to be uppermoſt, muſt alſo follow that direction, and mount up.

To account for two ſuch different actions, M. Dodart ſuppoſes that the fibres of the ſtalks are of ſuch a nature as to be contracted and ſhortened by the heat of the ſun, and lengthened out by the moiſture of the earth; and, on the contrary, that the fibres of the roots are contracted by the moiſture of the earth, and lengthened by the heat of the ſun. When the plantule therefore is inverted, and the root at the top, the fibres which compoſe one of the branches of the root are not alike expoſed to the moiſture of the earth, the lower part being more expoſed than the upper. The lower muſt of courſe contract the moſt; and this contraction is again promoted by the lengthening of the upper, whereon the ſun acts with the greateſt force. This branch of the root muſt therefore recoil towards the earth, and, inſinuating through the pores thereof, muſt get underneath the bulb, &c. By inverting this reaſoning we diſcover how the ſtalk comes to get uppermoſt.

We ſuppoſe then that the earth attracts the root to itſelf, and that the ſun contributes to its deſcent; and, on the other hand, that the ſun attracts the ſtem, and the earth contributes to ſend it towards the ſame. With reſpect to the ſtraightening of the ſtalks in the open air, our author imagines that it ariſes from the impreſſion of external cauſes, particularly the ſun and rain. For the upper part of a ſtalk that is bent is more expoſed to the rain, dew, and even the ſun, &c. than the under; and theſe cauſes, in a certain ſtructure of the fibres, both equally tend to ſtraighten the part moſt expoſed by the ſhortening they ſucceſſively occaſion in it; for moiſture ſhortens by ſwelling and heat by diſſipating. What that ſtructure is which gives the fibres ſuch different qualities, or whereon it depends, is a myſtery as yet beyond our depth.

M. de la Hire accounts for the perpendicularity of the ſtems or ſtalks of plants in this manner: he ſuppoſes that the root of plants draws a coarſer and heavier juice, and the ſtem and branches a finer and more volatile one. Moſt naturaliſts indeed conceive the root to be the ſtomach of the plant, where the juices of the earth are ſubtilized ſo as to become able to riſe through the ſtem to the extremity of the branches. This difference of juices ſuppoſes larger pores in the roots than the ſtalk, &c. and, in a word, a different contexture. This difference muſt be found even in the little inviſible plant incloſed in the ſeed: in it, therefore, we may conceive a point of ſeparation; ſuch as, that all on one ſide, for example the root, ſhall be unfolded by the groſſer juices, and all on the other ſide by the more ſubtile ones. Suppoſe the plantule, when its parts begin to unfold, to be entirely inverted, the root at the top, and the ſtalk below; the juices entering the root will be coarſeſt, and when they have opened and enlarged the pores ſo as to admit juices of a determinate weight, thoſe juices preſſing the root more and more will drive it downwards; and this will increaſe as the root is more extended or enlarged: for the point of ſeparation being conceived as the fixed point of a lever, they will act by the longer arm. The volatile juices at the ſame time having penetrated the ſtalk, will give it a direction from below upwards; and, by reaſon of the lever, will give it more and more every day. The little plant is thus turned on its fixed point of ſeparation till it become perfectly erect.

When the plant is thus erected, the ſtalk ſhould ſtill riſe perpendicularly, in order to give it the more firm biding, and enable it to withſtand the effort of wind and weather. M. Parent thus accounts for this effect: If the nutritious juice which arrived at the extremity of a riſing ſtalk evaporate, the weight of the air which encompaſſes it on all ſides will make it aſcend vertically: but if, inſtead of evaporating, it congeal, and remain fixed to that extremity whence it was ready to go off, the weight of the air will give it the ſame direction; ſo that the ſtalk will have acquired a ſmall new part vertically laid over it, juſt as the flame in a candle held in any way obliquely to the horizon ſtill continues vertical by the preſſure of the atmoſphere. The new drops of juice that ſucceed will follow the ſame direction; and as all together form the ſtalk, that muſt of courſe be vertical, unleſs ſome particular circumſtance intervene.

The branches, which are at firſt ſuppoſed to proceed laterally out of the ſtalk in the firſt embryo of the plant, though they ſhould even come out in an horizontal direction, muſt alſo raiſe themſelves upwards by the conſtant direction of the nutritious juice, which at firſt ſcarcely meets any reſiſtance in a tender ſupple branch; and afterwards, even though the branch grow more firm, it will act with the more advantage; ſince the branch, being become longer, furniſhes it with a longer arm or lever. The ſlender action of even a little drop becomes very conſiderable by its continuity, and by the aſſiſtance of ſuch circumſtances. Hence may we account for that regular ſituation and direction of the branches,

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branches, since they all make nearly the same constant angle of 45° with the stem, and with one another.

M. Astruc accounts for the perpendicularity of the stems, and their redressing themselves, thus: 1. He thinks the nutritious juice arises from the circumference of the plant, and terminates in the pith: And, 2. That fluids, contained in tubes either parallel or oblique to the horizon, gravitate on the lower part of the tubes, and not at all on the upper. Hence it follows, that, in a plant placed either obliquely or parallel to the horizon, the nutritious juice will act more on the lower part of the canals than on the upper; and by this means they will insinuate more into the canals communicating therewith, and be collected more copiously therein: thus the parts on the lower side will receive more accretion and be more nourished than those on the upper, the extremity of the plant will therefore be obliged to bend upwards.

This principle brings the seed into its due situation at first. In a bean planted upside down, the plume and radicle may be seen with the naked eye shooting at first directly for about an inch; after which they begin to bend, the one downward, and the other upward. The same is the case in a heap of barley to be made into malt, or in a quantity of acorns laid to sprout in a moist place, &c. Each grain of barley and each acorn has a different situation; and yet every sprout tends directly upward, and every root downward, and the curvity or bend they make is greater or less as their situation approaches more or less to the direction wherein no curvature at all would be necessary. But two such opposite motions cannot possibly arise without supposing some difference between the two parts: the only one we know of is, that the plume is fed by a juice imported to it by tubes parallel to its sides, whereas the radicle imbibes its nourishment at every pore in its surface. When the plume therefore is either parallel or inclined to the horizon, the nutritious juice, feeding the lower parts more than the upper, will determine its extremes to turn upward, for the reasons before given. On the contrary, when the radicle is in the like situation, the nutritious juice penetrating through the upper part more copiously than through the under, there will be a greater accretion of the former than of the latter; and the radicle will therefore be bent downwards, and this mutual curvity of the plume and radicle must continue till such time as their sides are nourished alike, which cannot be till they are perpendicular.

Of the Food of PLANTS.—This hath been so fully discussed under the article AGRICULTURE, that little remains to be said upon the subject in this place. The method of making dephlogisticated or vital air *de novo*, is now so much improved, that numberless experiments may be made with it both on animals and vegetables. It appears, indeed, that these two parts of the creation are a kind of counterbalance to one another; and the noxious parts or excrements of the one prove salutary food to the other. Thus, from the animal body continually pass off certain effluvia, which vitiate or *phlogisticate* the air. Nothing can be more prejudicial to animal life than an accumulation of these effluvia: on the other hand, nothing is more favourable to vegetables than those excrementitious effluvia of animals; and accordingly they greedily absorb them from the earth, or from the air. With respect to the excrementitious parts of living vegetables, the case is reversed. The purest air is the common effluvium which passes off from vegetables; and this, however favourable to animal life, is by no means so to vegetable; whence we have an additional proof of the doctrine concerning the food of plants delivered under the article AGRICULTURE.

With regard to the effects of other kinds of air on vegetation, a difference of some consequence took place between Dr Priestley and Dr Percival. The former, in the first volume of his Experiments and Observations on Air, had asserted that fixed air is fatal to vegetable as well as to animal life. This opinion, however, was opposed by Dr Percival, and the contrary one adopted by Dr Hunter of York in the Georgical Essays, vol. v. The experiments related by these two gentlemen would indeed have been decisive, had they been made with sufficient accuracy. That this was the case, however, Dr Priestley denies; and in the 3d volume of his Treatise on Air has fully detected the mistakes in Dr Percival's Experiments; which proceeded in fact from his having used, not fixed air, but common air mixed with a small quantity of fixed air. His experiments, when repeated with the purest fixed air, and in the most careful manner, were always attended with the same effect, namely, the killing of the plant.

It had also been asserted by Drs Percival and Hunter, that water impregnated with fixed air was more favourable to vegetation than simple water. This opinion was likewise examined by Dr Priestley: however, his experiments were indecisive; but seem rather unfavourable to the use of fixed air than otherwise.

Another very remarkable fact with regard to the food of plants has been discovered by Dr Priestley; namely, that some of them, such as the willow, comfrey, and duckweed, are nourished by inflammable air. The first, he says, flourishes in this species of air so remarkably, that, "it may be said to feed upon it with great avidity. *Priestley on Air*, vol. v. p. 2.
This process terminates in the change of what remains of the inflammable air into phlogisticated air, and sometimes into a species of air as good as common air, or even better; so that it must be the *inflammable principle* in the air that the plant takes, converting it, no doubt, into its proper nourishment."

What the followers of Stahl call phlogisticated air and inflammable air, are so closely allied to each other, that it is no wonder they should serve promiscuously for the food of plants. The reason why both are not agreeable to all kinds of plants, most probably is the different quantity of phlogistic matter contained in them, and the different action of the latent fire they contain; for all plants do not require an equal quantity of nourishment; and such as require but little, will be destroyed by having too much. The action of heat also is essentially necessary to vegetation; and it is probable that very much of this principle is absorbed from the air by vegetables. But if the air by which plants are partly nourished contains too much of that principle, it is very probable that they may be destroyed from this cause as well as the other; and thus inflammable air, which contains a vast quantity of that active principle, may destroy such plants as grow in a dry soil, though it preserves those which grow in a wet one. See VEGETATION.

Dissemination of PLANTS.—So great are the prolific powers of the vegetable kingdom, that a single plant almost of any kind, if left to itself, would, in a short time, overrun

overrun the whole world. Indeed, ſuppoſing the plant to have been only a ſingle annual, with two ſeeds, it would, in 20 years, produce more than a million of its own ſpecies; what numbers then muſt have been produced by a plant whoſe ſeeds are ſo numerous as many of thoſe with which we are acquainted? In that part of our work we have given particular examples of the very prolific nature of plants, which we need not repeat here; and we have made ſome obſervations on the means by which they are carried to diſtant places. This is a very curious matter of fact, and as ſuch we ſhall now give a fuller account of it.

If nature had appointed no means for the ſcattering of theſe numerous ſeeds, but allowed them to fall down in the place where they grew, the young vegetables muſt of neceſſity have choked one another as they grew up, and not a ſingle plant could have arrived at perfection. But ſo many ways are there appointed for the diſſemination of plants, that we ſee they not only do not hinder each others growth, but a ſingle plant will in a ſhort time ſpread through different countries. The moſt evident means for this purpoſe are,

1. The force of the air.—That the efficacy of this may be the greater, nature has raiſed the ſeeds of vegetables upon ſtalks, ſo that the wind has thus an opportunity of acting upon them with the greater advantage. The ſeed-capſules alſo open at the apex, leſt the ripe ſeeds ſhould drop out without being widely diſperſed by the wind. Others are furniſhed with wings, and a pappous down, by which, after they come to maturity, they are carried up into the air, and have been known to fly the diſtance of 50 miles: 138 genera are found to have winged ſeeds.

2. In ſome plants the ſeed-veſſels open with violence when the ſeeds are ripe, and thus throw them to a conſiderable diſtance; and we have an enumeration of 50 genera whoſe ſeeds are thus diſperſed.

3. Other ſeeds are furniſhed with hooks, by which, when ripe, they adhere to the coats of animals, and are carried by them to their lodging places. Linnæus reckons 50 genera armed in this manner.

4. Many ſeeds are diſperſed by means of birds and other animals; who pick up the berries, and afterwards eject the ſeeds uninjured. Thus the fox diſſeminates the privet, and man many ſpecies of fruit. The plants found growing upon walls and houſes, on the tops of high rocks, &c. are moſtly brought there by birds; and it is univerſally known, that by manuring a field with new dung, innumerable weeds will ſpring up which did not exiſt there before: 193 ſpecies are reckoned up which may be diſſeminated in this manner.

5. The growth of other ſeeds is promoted by animals in a different way. While ſome are eaten, others are ſcattered and trodden into the ground by them. The ſquirrel gnaws the cones of the pine, and many of the ſeeds fall out. When the loxia eats off their bark, almoſt his only food, many of their ſeeds are committed to the earth, or mixed in the moraſs with moſs, where he had retired. The glandularia, when ſhe hides up her nuts, often forgets them, and they ſtrike root. The ſame is obſervable of the walnut; mice collect and bury great quantities of them, and being afterwards killed by different animals, the nuts germinate.

6. We are aſtoniſhed to find moſſes, fungi, byſſus, and mucor, growing everywhere; but it is for want of reflecting that their ſeeds are ſo minute that they are almoſt inviſible to the naked eye. They float in the air like atoms, and are dropped everywhere, but grow only in thoſe places where there was no vegetation before; and hence we find the ſame moſſes in North America and in Europe.

7. Seeds are alſo diſperſed by the ocean, and by rivers. "In Lapland (ſays Linnæus), we ſee the moſt evident proofs how far rivers contribute to depoſite the ſeeds of plants. I have ſeen Alpine plants growing upon their ſhores frequently 36 miles diſtant from the Alps; for their ſeeds falling into the rivers, and being carried along and left by the ſtream, take root there.—We may gather likewiſe from many circumſtances how much the ſea furthers this buſineſs.—In Roſlagia, the iſland of Græſœa, Oeland, Gothland, and the ſhores of Scania, there are many foreign and German plants not yet naturalized in Sweden. The centaury is a German plant, whoſe ſeeds being carried by the wind into the ſea, the waves landed this foreigner upon the coaſts of Sweden. I was aſtoniſhed to ſee the veronica maritima, a German plant, growing at Tornea, which hitherto had been found only in Græſœa: the ſea was the vehicle by which this plant was tranſported thither from Germany; or poſſibly it was brought from Germany to Græſœa, and from thence to Tornea. Many have imagined, but erroneouſly, that ſeed corrupts in water, and loſes its principle of vegetation. Water at the bottom of the ſea is ſeldom warm enough to deſtroy ſeeds; we have ſeen water cover the ſurface of a field for a whole winter, while the ſeed which it contained remained unhurt, unleſs at the beginning of ſpring the waters were let down ſo low by drains, that the warmth of the ſun-beams reached to the bottom. Then the ſeeds germinate, but preſently become putreſcent; ſo that for the reſt of the year the earth remains naked and barren. Rain and ſhowers carry ſeeds into the cracks of the earth, ſtreams, and rivers; which laſt, conveying them to a diſtance from their native places, plant them in a foreign ſoil." *Amoen. Acad.*

8. Laſtly, ſome ſeeds aſſiſt their projection to a diſtance in a very ſurpriſing manner. The crupina, a ſpecies of centaury, has its ſeeds covered over with erect briſtles, by whoſe aſſiſtance it creeps and moves about in ſuch a manner, that it is by no means to be kept in the hand. If you confine one of them between the ſtocking and the foot, it creeps out either at the ſleeve or neck-band, travelling over the whole body. If the bearded oat, after harveſt, be left with other grain in the barn, it extricates itſelf from the glume; nor does it ſtop in its progreſs till it gets to the walls of the building. Hence, ſays Linnæus, the Dalecarlian, after he has cut and carried it into the barn, in a few days finds all the glumes empty, and the oats ſeparate from them; for every oat has a ſpiral ariſta or beard annexed to it, which is contracted in wet, and extended in dry weather. When the ſpiral is contracted, it drags the oat along with it: the ariſta being bearded with minute hairs pointing downward, the grain neceſſarily follows it; but when it expands again, the oat does not go back to its former place, the roughneſs of the beard the contrary way preventing its return. If you take the ſeeds of equiſetum, or fern, theſe being laid upon paper, and viewed in a microſcope, will be ſeen to leap over any obſtacle as if they had feet; by which they are ſeparated and diſperſed one from another; ſo that a perſon ignorant of this

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this property would pronounce these seeds to be so many mites or small insects.

We cannot finish this article without remarking, that many ingenious men believe that plants have a power of perception. Of this opinion we shall now give an account from the second volume of the Manchester Transactions, where we find some *speculations on the perceptive power of vegetables by Dr Percival*, who attempts to show, by the several analogies of organization, life, instinct, spontaneity, and self-motion, that plants, like animals, are endued with the powers both of perception and enjoyment. The attempt is ingenious, and is ingeniously supported, but in our opinion fails to convince. That there is an analogy between animals and vegetables is certain; but we cannot from thence conclude that they either perceive or enjoy. Botanists have, it is true, derived from *anatomy* and *physiology*, almost all the terms employed in the description of plants. But we cannot from thence conclude, that their organization, though it bears an analogy to that of animals, is the sign of *a living principle*, if to this *principle* we annex the idea of *perception*; yet so fully is our author convinced of the truth of it, that he does not think it extravagant to suppose, that, in some future period, perceptivity may be discovered to extend even beyond the limits now assigned to vegetable life. Corallines, madrepores, millepores, and sponges, were formerly considered as fossil bodies: but the experiments of Count Marsigli evinced, that they are endued with life, and led him to class them with the maritime plants. And the observations of Ellis, Jussieu, and Peysonel, have since raised them to the rank of animals. The detection of error, in long established opinions concerning one branch of natural knowledge, justifies the suspicion of its existence in others, which are nearly allied to it. And it will appear from the prosecution of our inquiry into the instincts, spontaneity, and self-moving power of vegetables, that the suspicion is not without foundation.

He then goes on to draw a comparison between the instincts of animals and those of vegetables; the calf, as soon as it comes into the world, applies to the teats of the cow; and the duckling, though hatched under a hen, runs to the water.

"Instincts analogous to these (says our author), operate with equal energy on the vegetable tribe. A seed contains a germ, or plant in miniature, and a radicle, or little root, intended by nature to supply it with nourishment. If the seed be sown in an inverted position, still each part pursues its proper direction. The plumula turns upward, and the radicle strikes downward into the ground. A hop-plant, turning round a pole, follows the course of the sun, from south to west, and soon dies, when forced into an opposite line of motion: but remove the obstacle, and the plant will quickly return to its ordinary position. The branches of a honeysuckle shoot out longitudinally, till they become unable to bear their own weight; and then strengthen themselves, by changing their form into a spiral: when they meet with other living branches, of the same kind, they coalesce, for mutual support, and one spiral turns to the right and the other to the left; thus seeking, by an instinctive impulse, some body on which to climb, and increasing the probability of finding one by the diversity of their course: for if the auxiliary branch be dead, the other uniformly winds itself round from the right to the left.

"These examples of the instinctive economy of vegetables have been purposely taken from subjects familiar to our daily observation. But the plants of warmer climates, were we sufficiently acquainted with them, would probably furnish better illustrations of this acknowledged power of animality: and I shall briefly recite the history of a very curious exotic, which has been delivered to us from good authority; and confirmed by the observations of several European botanists."

The doctor then goes on to give a description of the *dionæa muscipula* (B), for which see vol. vi. p. 32.; and concludes, that if he has furnished any presumptive proof of the instinctive power of vegetables, it will necessarily follow that they are endued with some degree of spontaneity. More fully to evince this, however, the doctor points out a few of those phenomena in the vegetable kingdom which seem to indicate spontaneity.— "Several years ago (says he), whilst engaged in a course of experiments to ascertain the influence of fixed air on vegetation, the following fact repeatedly occurred to me. A sprig of mint, suspended by the root, with the head downwards,

(B) Dr Watson, the bishop of Landaff, who has espoused the same side of the question with Dr Percival (see the 5th vol. of his Chemical Essays), reasons thus on the motions of vegetables. "Whatever can produce any effect (says he) upon an animal organ, as the impact of external bodies, heat and cold, the vapour of burning sulphur, of volatile alkali, want of air, &c. are found to act also upon the plants called *sensitive*. But not to insist upon any more instances, the muscular motions of the dionæa muscipula, lately brought into Europe from America, seem far superior in quickness to those of a variety of animals. Now to refer the muscular motions of shell-fish and zoophytes to an internal principle of volition, to make them indicative of the perceptivity of the being, and to attribute the more notable ones of vegetables to certain mechanical dilatations and contractions of parts occasioned by external impulse, is to err against that rule of philosophizing which assigns the same causes for effects of the same kind. The motions in both cases are equally accommodated to the preservation of the being to which they belong, are equally distinct and uniform, and should be equally derived from mechanism, or equally admitted as criterions of perception.

"I am sensible that these and other similar motions of vegetables may by some be considered as analogous to the automatic or involuntary motions of animals; but as it is not yet determined amongst the physiologists, whether the motion of the heart, the peristaltic motion of the bowels, the contractions observable upon external impulse in the muscles of animals deprived of their heads and hearts, be attributable to an irritability unaccompanied with perceptivity, or to an uneasy sensation, there seems to be no reason for entering into so obscure a disquisition; especially since irritability, if admitted as the cause of the motions of vegetables, must *à fortiori* be admitted as the cause of the less exquisite and discernible motions of being universally referred to the animal kingdom."

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downwards, in the middle glass vessel of Dr Nooth's machine, continued to thrive vigorously, without any other pabulum than what was supplied by the stream of mephitic gas to which it was exposed. In 24 hours the stem formed into a curve, the head became erect, and gradually ascended towards the mouth of the vessel; thus producing, by successive efforts, a new and unusual configuration of its parts. Such exertions in the sprig of mint, to rectify its inverted position, and to remove from a foreign to its natural element, seems to evince evolition to avoid what was evil, and to recover what had been experienced to be good. If a plant, in a garden-pot, be placed in a room which has no light except from a hole in the wall, it will shoot towards the hole, pass through it into the open air, and then vegetate upwards in its proper direction. Lord Kames relates, that, 'amongst the ruins of New Abbey, formerly a monastery in Galloway, there grows on the top of a wall a plane tree, 20 feet high. Straitened for nourishment in that barren situation, it several years ago directed roots down the side of the wall till they reached the ground ten feet below: and now the nourishment it afforded to these roots, during the time of descending, is amply repaid; having every year since that time made vigorous shoots. From the top of the wall to the surface of the earth, these roots have not thrown out a single fibre, but are now united into a pretty thick hard root.'

"The regular movements by which the sun-flower presents its splendid disk to the sun have been known to naturalists, and celebrated by poets, both of ancient and modern times. Ovid founds upon it a beautiful story; and Thomson describes it as an attachment of love to the celestial luminary.

'But one, the lofty follower of the sun,
'Sad when he sets, shuts up her yellow leaves,
'Drooping all night; and when he warm returns,
'Points her enamour'd bosom to his ray.'

SUMMER, line 216.

Dr Percival next touches on motion; he mentions corallines, sea-pens*, oysters, &c. as endued with the power of motion in a very small degree, and then he speaks in the following manner. "Mr Miller (says he), in his late account of the island of Sumatra, mentions a species of coral, which the inhabitants have mistaken for a plant, and have denominated it *lalan-cout*, or sea-grass. It is found in shallow bays, where it appears like a straight stick, but when touched withdraws itself into the sand. Now if self-moving faculties like these indicate animality, can such a distinction be denied to vegetables, possessed of them in an equal or superior degree? The water-lily, be the pond deep or shallow in which it grows, pushes up its flower-stems till they reach the open air, that the farina fecundans may perform without injury its proper office. About seven in the morning the stalk erects itself, and the flowers rise above the surface of the water: in this state they continue till four in the afternoon, when the stalk becomes relaxed, and the flowers sink and close. The motions of the sensitive plant have been long noticed with admiration, as exhibiting the most obvious signs of perceptivity. And if we admit such motions as criteria of a like power in other beings, to attribute them in this instance to mere mechanism, actuated solely by external impulse, is to deviate from the soundest rule of philosophizing, which directs us not to multiply causes when the effects appear to be the same. Neither will the laws of electricity better solve the phenomena of this animated vegetable: for its leaves are equally affected by the contact of electric and non-electric bodies; show no change in their sensibility whether the atmosphere be dry or moist; and instantly close when the vapour of volatile alkali or the fumes of burning sulphur are applied to them. The powers of chemical stimuli to produce contractions in the fibres of this plant may perhaps lead some philosophers to refer them to the *vis insita*, or irritability, which they assign to certain parts of organized matter, totally distinct from, and independent of, any sentient energy. But the hypothesis is evidently a solecism, and refutes itself. For the presence of irritability can only be proved by the experience of irritations, and the idea of irritation involves in it that of feeling.

* See *Pennatula*, *Ostrea*, *Mytilus*, &c.

"But there is a species of the order of decandria, which constantly and uniformly exerts a self-moving power, uninfluenced either by chemical stimuli, or by any external impulse whatsoever. This curious shrub, which was unknown to Linnæus, is a native of the East Indies, but has been cultivated in several botanical gardens here. I had an opportunity of examining it in the collection of the late Dr Brown. See HEDYSARUM.—I cannot better comment on this wonderful degree of vegetable animation than in the words of Cicero. *Inanimum est omne quod pulsu agitatur externo; quod autem est animal, id motu cietur interiore et suo.*

"I have thus attempted, with the brevity prescribed by the laws of this society, to extend our views of animated nature; to gratify the mind with the contemplation of multiplied accessions to the general aggregate of felicity; and to exalt our conceptions of the wisdom, power, and beneficence of God. In an undertaking never yet accomplished, disappointment can be no disgrace: in one directed to such noble objects, the motives are a justification, independently of success. Truth, indeed, obliges me to acknowledge, that I review my speculations with much diffidence; and that I dare not presume to expect they will produce any permanent conviction in others, because I experience an instability of opinion in myself. For, to use the language of Tully, *Nescio quomodo, dum lego, assentior; cum posui librum, assensio omnis illa elabitur.*—But this scepticism is perhaps to be ascribed to the influence of habitual preconceptions, rather than to a deficiency of reasonable proof. For besides the various arguments which have been advanced in favour of vegetable perceptivity, it may be further urged, that the hypothesis recommends itself by its consonance to those higher analogies of nature, which lead us to conclude, that the greatest possible sum of happiness exists in the universe. The bottom of the ocean is overspread with plants of the most luxuriant magnitude. Immense regions of the earth are covered with perennial forests. Nor are the Alps, or the Andes, destitute of herbage, though buried in deeps of snow. And can it be imagined that such profusion of life subsists without the least sensation or enjoyment? Let us rather, with humble reverence, suppose, that vegetables participate, in some low degree, of the common allotment of vitality; and that our great Creator hath apportioned

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apportioned good to all living things, ' in number, weight, and meafure." See *SENSITIVE Plant*, MIMOSA, *DIONÆA Mufcipula*, *Vegetable MOTION*, &c.

To thefe ingenious and fpirited obfervations, we fhall fubjoin nothing of our own, but leave our readers to determine for themfelves (C). Speculations of this kind, when carried on by fober men, will never be productive of bad confequences; but by the fubtle fceptic, or the more unwary inquirer, they may be made the engine of very dangerous errors. By this we do not mean to infinuate that the fpirit of inquiry fhould be fuppreffed, becaufe that fpirit, in the hands of weak or of wicked men, may be abufed. By thofe, however, who know the bad confequences that may be drawn, and indeed that have been drawn, from the opinions we have now given an account of, our caution will not be deemed impertinent.

PLANTS growing on Animals. See *INSECTS giving root to Plants.*

Sexes of PLANTS. See SEXES and BOTANY.

Colours of PLANTS. See *COLOUR of Plants.*

Colours extracted from PLANTS. See *COLOUR-making.*

Method of Drying and Preferving PLANTS for Botanifts.—Many methods have been devifed for the prefervation of plants: we fhall relate only thofe that have been found moft fuccefsful.

Withering's Botanical Arrangement, Introd. p. 48.

Firft prepare a prefs, which a workman will make by the following directions. Take two planks of wood not liable to warp. The planks muft be two inches thick, 18 inches long, and 12 inches broad. Get four male and four female fcrews, fuch as are commonly ufed for fecuring fafh windows. Let the four female fcrews be let into the four corners of one of the planks, and correfponding holes made through the four corners of the other plank for the male fcrews to pafs through, fo as to allow the two planks to be fcrewed tightly together. It will not be amifs to face the bearing of the male fcrews upon the wood with iron plates; and if the iron plates went acrofs from corner to corner of the wood, it would be a good fecurity againft the warping.

Secondly, get half a dozen quires of large foft fpongy paper (fuch as the ftationers call *bloffom blotting paper* is the beft), and a few fheets of ftrong pafteboard.

The plants you wifh to preferve fhould be gathered in a dry day, after the fun hath exhaled the dew; taking particular care to collect them in that ftate wherein their generic and fpecific characters are moft confpicuous. Carry them home in a tin box nine inches long, four inches and a half wide, and one inch and a half deep. Get the box made of the thinneft tinned iron that can be procured; and let the lid open upon hinges. If any thing happen to prevent the immediate ufe of the fpecimens you have collected, they will be kept frefh two or three days in this box much better than by putting them in water. When you are going to preferve them, fuffer them to lie upon a table until they become limber; and then they fhould be laid upon a pafteboard, as much as poffible in their natural form, but at the fame time with a particular view to their generic and fpecific characters. For this purpofe it will be adviseable to feparate one of the flowers, and to difplay the generic character. If the fpecific character depend upon the flower or upon the root, a particular difplay of that will be likewife neceffary. When the plant is thus difpofed upon the pafteboard, cover it with eight or ten layers of fpongy paper, and put it into the prefs. Exert only a fmall degree of preffure for the firft two or three days; then examine it, unfold any unnatural plaits, rectify any miftakes, and, after putting frefh paper over it, fcrew the prefs harder. In about three days more feparate the plant from the pafteboard, if it is fufficiently firm to allow of a change of place; put it upon a frefh pafteboard, and, covering it with frefh bloffom paper, let it remain in the prefs a few days longer. The prefs fhould ftand in the funfhine, or within the influence of a fire.

When it is perfectly dry, the ufual method is to faften it down, with pafte or gum water, on the right-hand inner page of a fheet of large ftrong writing-paper. It requires fome dexterity to glue the plant neatly down, fo that none of the gum or pafte may appear to defile the paper. Prefs it gently again for a day or two, with a half fheet of bloffom-paper betwixt the folds of the writing paper. When it is quite dry, write upon the left-hand inner page of the paper the name of the plant; the fpecific character; the place where, and the time when, it was found; and any other remarks you may think proper. Upon the back of the fame page, near the fold of the paper, write the name of the plant, and then place it in your cabinet. A fmall quantity of finely powdered arfenic, or corrofive fublimate, is ufually mixed with the pafte or gum-water, to prevent the devaftations of infects; but the feeds of ftaves-acre finely powdered will anfwer the fame purpofe, without being liable to corrode or to change the colour of the more delicate plants. Some people put the dried plants into the fheets of writing paper, without faftening them down at all; and others only faften them by means of fmall flips of paper, pafted acrofs the ftem or branches. Where the fpecies of any genus are numerous, and the fpecimens are fmall, feveral of them may be put into one fheet of paper.

Another more expeditious method is to take the plants out of the prefs after the firft or fecond day; let them remain upon the pafteboard; cover them with five or fix leaves of bloffom paper, and iron them with a hot fmoothing

(C) In the 2d volume of *Tranfactions of the Linnæan Society*, we find Dr Percival's reafoning very ably combated, as far as he draws his confequences from the external motions of plants; where it is argued, that thefe motions, though in fome refpects fimilar to thofe of animals, can and ought to be explained, without concluding that they are endowed either with perception or volition. Mr Townfon concludes his paper in thefe words: " When all is confidered (fays he), I think we fhall place this opinion among the many ingenious flights of the imagination, and foberly follow that blind impulfe which leads us naturally to give fenfation and perceptivity to animal life, and to deny it to vegetables; and fo ftill fay with Ariftotle, and our great mafter Linnæus, *Vegetabilia crefcunt & vivunt; animalia crefcunt, vivunt, & fentiunt.*"

ſmoothing iron until they are perfectly dry. If the iron be too hot, it will change the colours; but ſome people, taught by long practice, will ſucceed very happily. This is quite the beſt method to treat the orchis and other ſlimy mucilaginous plants.

Another method is to take the plants when freſh gathered, and, inſtead of putting them into the preſs, immediately to faſten them down to the paper with ſtrong gum water: then dip a camel-hair pencil into ſpirit-varniſh, and varniſh the whole ſurface of the plant two or three times over. This method ſucceeds very well with plants that are readily laid flat, and it preſerves their colours better than any other. The ſpirit varniſh is made thus. To a quart of highly rectified ſpirit of wine put five ounces of gum ſandarach; two ounces of maſtich in drops; one ounce of pale gum elemi, and one ounce of oil of ſpike-lavender. Let it ſtand in a warm place, and ſhake it frequently to expedite the ſolution of the gums.

Where no better convenience can be had, the ſpecimens may be diſpoſed ſyſtematically in a large folio book; but a vegetable cabinet is upon all accounts more eligible. With the aſſiſtance of the following deſcription a workman may readily make one. The drawers muſt have backs and ſides, but no other front than a ſmall ledge. Each drawer will be 14 inches wide, and 10 inches from the back to the front, after allowing half an inch for the thickneſs of the two ſides, and a quarter of an inch for the thickneſs of the back. The ſides of the drawers, in the part next the front, muſt be ſloped off in a ſerpentine line, ſomething like what the workmen call an *ogee*. The bottoms of the drawers muſt be made to ſlide in grooves cut in the uprights, ſo that no ſpace may be loſt betwixt drawer and drawer. After allowing a quarter of an inch for the thickneſs of the bottom of each drawer, the clear perpendicular ſpace in each muſt be as in the following table.

I. Two tenths of an inch.
II. One inch and two-tenths.
III. Four inch. and ſix-tenths.
IV. Two inches and three-tenths.
V. Seven inches and eight-tenths.
VI. Two inches and two-tenths.
VII. Two tenths of an inch.
VIII. One inch and four-tenths.
IX. Two-tenths of an inch.
X. Two inches and eight-tenths.
XI. One inch and two-tenths,
XII. Three inches and five-tenths.
XIII. Two inches and four-tenths.
XIV. Three inches and eight-tenths.
XV. Three inches and four-tenths.
XVI. One inch and three-tenths.
XVII. Two inches and eight-tenths.
XVIII. Six-tenths of an inch.
XIX. Ten inches.
XX. One inch and nine-tenths.
XXI. Four inches and four-tenths.
XXII. Two inches and ſix-tenths.
XXIII. One inch and two-tenths.
XXIV. Seventeen inches.

This cabinet ſhuts up with two doors in front; and the whole may ſtand upon a baſe, containing a few drawers for the reception of duplicates and papers.

Foſſil PLANTS. Many ſpecies of tender and herbaceous plants are found at this day, in great aboundance, buried at conſiderable depths in the earth, and converted, as it were, into the nature of the matter they lie among; foſſil wood is often found very little altered, and often impregnated with ſubſtances of almoſt all the different foſſil kinds, and lodged in all the ſeveral ſtrata, ſometimes firmly imbedded in hard matter; ſometimes looſe: but this is by no means the caſe with the tenderer and more delicate ſubjects of the vegetable world. Theſe are uſually immerſed either in a blackiſh ſlaty ſubſtance, found lying over the ſtrata of coal, elſe in looſe nodules of ferruginous matter of a pebble-like form, and they are always altered into the nature of the ſubſtance they lie among: what we meet with of theſe are principally of the fern kind; and what is very ſingular, though a very certain truth, is, that theſe are principally the ferns of American growth, not thoſe of our own climate. The moſt frequent foſſil plants are the polypody, ſpleenwort, oſmund, trichomanes, and the ſeveral larger and ſmaller ferns; but beſides theſe there are alſo found pieces of the equiſetum or horſe-tail, and joints of the ſtellated plants, as the clivers, madder, and the like; and theſe have been too often miſtaken for flowers; ſometimes there are alſo found complete graſſes, or parts of them, as alſo reeds, and other watery plants; ſometimes the ears of corn, and not unfrequently the twigs or bark, and impreſſions of the bark and fruit of the pine or fir kind, which have been, from their ſcaly appearance, miſtaken for the ſkins of fiſhes; and ſometimes, but that very rarely, we meet with moſſes and ſea-plants.

Many of the ferns not unfrequently found, are of very ſingular kinds, and ſome ſpecies yet unknown to us; and the leaves of ſome appear ſet at regular diſtances, with round protuberances and cavities. The ſtones which contain theſe plants ſplit readily, and are often found to contain, on one ſide, the impreſſion of the plant, and on the other the prominent plant itſelf; and, beſide all that have been mentioned, there have been frequently ſuppoſed to have been found with us ears of common wheat, and of the maize or Indian corn; the firſt being in reality no other than the common endmoſt branches of the firs, and the other the thicker boughs of various ſpecies of that and of the pine kind, with their leaves fallen off; ſuch branches in ſuch a ſtate cannot but afford many irregular tubercles and papillæ, and, in ſome ſpecies, ſuch as are more regularly diſpoſed.

Theſe are the kinds moſt obvious in England; and theſe are either immerſed in the ſlaty ſtone which conſtitutes whole ſtrata, or in flatted nodules uſually of about three inches broad, which readily ſplit into two pieces on being ſtruck.

They are moſt common in Kent, in coal-pits near Newcaſtle, and the foreſt of Dean in Glouceſterſhire; but are more or leſs found about almoſt all our coal-pits, and many of our iron mines. Though theſe ſeem the only ſpecies of plants found with us, yet in Germany there are many others, and thoſe found in different ſubſtances. A whitiſh ſtone, a little harder than chalk, frequently contains them: they are found alſo often in a gray ſlaty ſtone of a firmer texture, not unfrequently in a blackiſh one, and at times in many others. Nor are the bodies themſelves leſs various here than the matter in which they are contained: the leaves of trees are found in great abundance, among which thoſe of the willow, poplar, white thorn, and pear trees, are the moſt common; ſmall branches of box, leaves of the olive tree, and ſtalks of garden thyme, are alſo found there; and ſometimes ears of the various ſpecies of corn, and the larger as well as the ſmaller moſſes in great abundance.

Theſe ſeem the tender vegetables, or herbaceous plants, certainly found thus immerſed in hard ſtone, and buried at great depths in the earth: others of many kinds there are alſo named by authors; but as in bodies ſo imperfect errors are eaſily fallen into, theſe ſeem all that can be aſcertained beyond mere conjecture.

PLANTS, method of preſerving them in their original ſhape and colour. Waſh a ſufficient quantity of fine ſand, ſo as perfectly to ſeparate it from all other ſubſtances; dry it; paſs it through a ſieve to clear it from any groſs particles which would not riſe in the waſhing: take an earthen veſſel of a proper ſize and form, for every plant and flower which you intend to preſerve; gather your plants and flowers when they are in a ſtate of perfection, and in dry weather, and always with a convenient portion of the ſtalk: heat a little of the dry ſand prepared as above, and lay it in the bottom of the veſſel, ſo as equally to cover it; lay the plant or flower upon it ſo as that no part of it may touch the ſides of the veſſel: ſift or ſhake in more of the ſame ſand by little upon it, ſo that the leaves may be extended by degrees, and without injury, till the plant or flower is covered about two inches thick: put the veſſel into a ſtove, or hot-houſe, heated by little and little to the 50th degree; let it ſtand there a day or two, or perhaps more, according to the thickneſs and ſucculence of the flower or plant; then gently ſhake the ſand out upon a ſheet of paper, and take out the plant, which you will find in all its beauty, the ſhape as elegant, and the colour as vivid as when it grew.

Some flowers require certain little operations to preſerve the adherence of their petals, particularly the tulip; with reſpect to which it is neceſſary, before it is buried in the ſand, to cut the triangular fruit which riſes in the middle of the flower; for the petals will then remain more firmly attached to the ſtalk.

A hortus ſiccus prepared in this manner would be one of the moſt beautiful and uſeful curioſities that can be.

Moving PLANT. See HEDYSARUM, BOTANY *Index.*

Sea PLANTS. See *SEA Plants.*

Senſitive PLANT. See MIMOSA, BOTANY *Index.*

PLANT-Lice, Vine-fretters, or *Pucerons.* See APHIS, ENTOMOLOGY *Index.*

PLANTA, a PLANT. See PLANT.

PLANTA Fœminea, a female plant, is one which bears female flowers only. It is oppoſed to a *male* plant, which bears only male flowers; and to an *androgynous* one, which bears flowers of both ſexes. Female plants are produced from the ſame ſeed with the male, and arrange themſelves under the claſs of diœcia in the ſexual method.

PLANTAGENET, the ſurname of the kings of England from Henry II. to Richard III. incluſive. Antiquarians are much at a loſs to account for the origin of this name; and the beſt derivation they can find for it is, that Fulk, the firſt earl of Anjou of that name, being ſtung with remorſe for ſome wicked action, went in pilgrimage to Jeruſalem as a work of atonement; where, being ſoundly ſcourged with broom twigs, which grew plentifully on the ſpot, he ever after took the ſurname of *Plantagenet* or *broomſtalk,* which was retained by his noble poſterity.

PLANTAGO, PLANTAIN; a genus of plants belonging to the tetrandria claſs. See BOTANY *Index.*—Of the plantain there are the following ſpecies: The common broad-leaved plantain, called *waybred,* or *wayborn;* becauſe it commonly grows by the wayſide; the great hoary plantain, or lambs-tongue; the narrow-leaved plantain, or ribwort.

PLANTAIN. See PLANTAGO, BOTANY *Index.*

PLANTAIN-Tree. See MUSA, BOTANY *Index.*

PLANTATION, in the Weſt Indies, denotes a ſpot of ground which a planter, or perſon arrived in a new colony, pitches on to cultivate for his own uſe, or is aſſigned for that purpoſe. However, the term *plantation* is often uſed in a term ſynonymous with colony. See COLONY.

PLANTERSHIP, in a general ſenſe, the buſineſs of a planter.

PLANTERSHIP, in the Weſt Indies, denotes the management of a ſugar plantation, including not only the cultivation of the cane, but the various proceſſes for the extraction of the ſugar, together with the making of ſugar-ſpirits. See RUM, SACCHARUM, and SUGAR.

To effect a deſign ſo comprehenſive, it is neceſſary for a planter to underſtand every branch of the art preciſely, and to uſe the utmoſt attention and caution both in the laying down and executing of his plans. It is therefore the duty of a good planter to inſpect every part of his plantation with his own eyes; to place his proviſions, ſtores, and utenſils, in regular order, and in ſafe repoſitories; that by preſerving them in perfection, all kinds of waſte may be prevented.

But as negroes, cattle, mules, and horſes, are as it were the nerves of a ſugar-plantation, it is expedient to treat that ſubject with ſome accuracy.

Of Negroes, Cattle, &c.]. In the firſt place, then, as it is the intereſt of every planter to preſerve his negroes in health and ſtrength; ſo every act of cruelty is not leſs repugnant to the maſter's real profit, than it is contrary to the laws of humanity: and if a manager conſiders his own eaſe and his employer's intereſt, he will treat all negroes under his care with due benevolence; for good diſcipline is by no means inconſiſtent with humanity: on the contrary, it is evident from experience, that he who feeds his negroes well, proportions their labour to their age, ſex, and ſtrength, and treats them with kindneſs and good nature, will reap a much larger product, and with infinitely more eaſe and ſelf-ſatisfaction, than the moſt cruel taſkmaſter, who ſtarves his negroes, or chaſtiſes them with undue ſeverity. Every planter then who wiſhes to grow rich with eaſe, muſt be a good economiſt; muſt feed his negroes with the moſt wholeſome food, ſufficient to preſerve them in health and vigour. Common experience points out the methods by which a planter may preſerve his people in health and ſtrength. Some of his moſt fruitful land ſhould be allotted to each negro in proportion to his family, and a ſufficient portion of time allowed for the cultivation of it; but becauſe ſuch allotment cannot in long droughts produce enough for his comfortable ſupport, it is the incumbent duty of a good planter to have always his ſtores well filled with Guinea corn, yams, or eddoes, beſides potatoes growing in regular ſucceſſion: for plenty begets cheerfulneſs of heart, as well as ſtrength of body; by which more work is effected in a day by the ſame hands than in a week when enervated by want and ſeverity. Scanty meals may ſuſtain life; but it is evident, that more is requiſite to enable a negro or any other perſon to go through the neceſſary labours. He, therefore, who will reap plentifully, muſt plant great abundance of proviſions as well

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as

as ſugar-canes; and it is nature's economy ſo to fructify the ſoil by the growth of yams, plantains, and potatoes, as to yield better harveſts of ſugar, by that very means, than can be produced by many other arts of cultivation. Plantains are the principal ſupport of all the negroes in Jamaica; and are alſo much cultivated, at great expence of manure, in Barbadoes; but ought not to be ſolely depended upon in climates ſubject to hurricanes. A celebrated planter and economiſt of the laſt-mentioned iſland, who raiſed an immenſe fortune from very ſmall beginnings only by planting, affirmed, that he fed conſtantly at leaſt 300 negroes out of 12 acres of plantains. How that excellent produce came to be ſo long neglected in ſome of the iſlands it is hard to gueſs; but at preſent the neglect ſeems to be founded upon a vulgar error, that plantains cannot thrive in any other than low moiſt ſoils. In ſuch places, no doubt, they flouriſh moſt luxuriantly; but yet they thrive and bear fruit abundantly on mountains and in marſhes, and in the drieſt black mould upon marle or rocks, and even in ſharp gravelly ſoils, as may be evinced by numberleſs inſtances.

However plenty of wholeſome food may be conducive to health, there are alſo other means, equally neceſſary to the ſtrength and longevity of negroes, well worth the planter's attention: and thoſe are, to chooſe airy dry ſituations for their houſes; and to obſerve frequently that they be kept clean, in good repair, and perfectly water-tight; for naſtineſs, and the inclemencies of weather, generate the moſt malignant diſeaſes. If theſe houſes are ſituated alſo in regular order, and at due diſtances, the ſpaces may at once prevent general devaſtations by fire, and furniſh plenty of fruits and pot-herbs, to pleaſe an unvitiated palate, and to purify the blood. Thus then ought every planter to treat his negroes with tenderneſs and generoſity, that they may be induced to love and obey him out of mere gratitude, and become real good beings by the imitation of his behaviour; and therefore a good planter, for his own eaſe and happineſs, will be careful of ſetting a good example.

Having thus hinted the duties of a planter to his negroes, let the next care be of cattle, mules, and horſes. The planters of Barbadoes (who are perhaps the moſt ſkilful of all others, and exact to a nicety in calculations of profit and loſs), are, with reſpect to their cattle, the moſt remiſs of any in all the iſlands; as if the carriage of canes to the mill, and of plantation-produce to the market, was not as eſſential as any other branch of plantership. At Barbadoes, in particular, the care of theſe animals is of more importance: becauſe the ſoil, worn out by long culture, cannot yield any produce without plenty of dung. Some planters are nevertheleſs ſo ingeniouſly thrifty, as to carry their canes upon negroes heads; acting in that reſpect diametrically oppoſite to their own apparent intereſt, which cannot be ſerved more effectually than by ſaving the labour of human hands, in all caſes where the labour of brutes can be ſubſtituted; and for that end, no means of preſerving thoſe creatures in health and ſtrength ought to be neglected.

The firſt care therefore is to provide plenty and variety of food. In crop-time, profuſion of cane-tops may be had for the labour of carriage; but they will be more wholeſome and nutritious if tedded like hay by the ſun's heat, and ſweated by laying them in heaps a few days before they are eaten. In this ſeaſon of abundance, great ricks of cane-tops (the butt ends turned inwards) ſhould be made in the moſt convenient corner of each field, to ſupply the want of paſturage and other food: and theſe are very wholeſome if chopped into ſmall parts, and mixed ſometimes with common ſalt or ſprinkled with melaſſes mixed with water: but yet the cattle require change of food to preſerve them in ſtrength; ſuch as Guinea-corn, and a variety of graſs, which every ſoil produces with a little care in moiſt weather; and indeed this variety is found neceſſary in all climes.

But ſince that variety is not to be had during thoſe ſevere droughts to which hot climates are liable, and much leſs in thoſe ſmall iſlands which cannot furniſh large tracts of meadow-lands for hay, the only reſource is the fodder of cane-tops or tedded Guinea-corn leaves; which are very nutritious, and may be preſerved in perfection for more than a whole year, provided the tops or Guinea-corn are well tedded for three or four hot days as they lie ſpread in the field; and then, being tied into bundles or ſheaves, muſt lie in the hot ſun for three or four days more, when they may be fit to be put up into ricks. The beſt method of making them is in an oblong figure, about 30 feet in length, and 16 or 18 feet wide; ſeven feet high at the ſides, and from thence ſloping like the roof of an houſe, the ridge of which muſt be thatched very carefully; for the ſides may be ſecured from wet by placing the bundles with the butts upwards towards the ridge, in courſes, and lapping the upper over the lower courſe.

The beſt method of forming thoſe ricks is to place the firſt courſe of bundles all over the baſe one way; the ſecond courſe reverſely; and ſo alternately till the rick be finiſhed.

When cattle are to be fed with this fodder, it muſt be obſerved to take down the bundles from the top, at the weſt end of the rick, to the bottom; for all theſe ricks muſt ſtand eaſt and weſt lengthwiſe, as well to ſecure them from being overturned by high winds, as for the convenience of preſerving them from wet, which cannot be done when ricks are made round. By this huſbandry, an herd of cattle may be kept in ſtrength, either in ſevere droughts, or in wet ſeaſons when graſs is purgative; and thus the neceſſity or expence of large paſtures may be totally ſaved. The hay-knife uſed in England for cutting hay, anſwers for cutting ricks of tops.

The method of tedding Guinea-corn to make a kind of hay, will require a little explanation here. When Guinea-corn is planted in May, and to be cut down in July, in order to bear ſeed that year, that cutting, tedded properly, will make an excellent hay, which cattle prefer to meadow hay. In like manner, after Guinea-corn has done bearing ſeed, the after crop will furniſh a great abundance of that kind of fodder which will keep well in ricks for two or three years.

The next care of a planter is to provide ſhade for his cattle; either by trees where they are fed in the heat of the day, if his ſoil requires not dung; or by building a flat ſhed over the pen where cattle are confined for making it. That ſuch ſhades are eſſentially neceſſary to the well-being of all animals in hot weather, is apparent to every common obſerver, who cannot fail of ſeeing each creature forſaking the moſt luxuriant paſtures in the heat of the day for the ſake of ſhade; thus convincing

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vincing the owners, by instinctive argument, that shade is almost as necessary to the well-being of the brute creatures as food. Yet, notwithstanding that demonstration from the unerring course of nature, throughout all our islands (except in a very few instances), these poor creatures are exposed to the scorching sun-beams without mercy. Such inhuman neglect is not always so much the effect of inattention as of a mistaken notion that sheds are impedimental to the making of much dung; but a flat shed, covered with cane-trash, may be so made as to let rain pass through it without admission of sun-beams. This will do for cattle; but mules, which are spirited creatures, and work themselves by draught into a foaming heat, should be put into a warm stable, until quite cool: for turning them loose to pasture when so hot, is probably the cause of their destruction by the glanders.

If the care of providing shade for brute creatures is so much the duty and interest of their owners, how much more is it agreeable to the laws of humanity to provide shade for human creatures travelling upon the high-roads in this hot climate? Nothing surely of so much beauty costs so little expence as planting cocoa-nut or spreading timber trees in avenues along the highways, if each proprietor of the lands adjoining hath any taste of elegance, or feeling for other men: but both those kinds of trees will yield also great profit to the proprietor, by furnishing him with timber, when perhaps not otherwise to be had; or with a delicious milk, fitted by nature to cool the effervescence of the blood in this hot region; and also to improve the spirits made from sugar to the delicacy and softness of arrack. Cocoa-nut and cabbage-trees are both very beautiful and shady, bearing round heads of great expansion, upon natural trunks or pillars of elegant proportion, and of such an height as to furnish a large shade, with a free circulation of air equally refreshing to man and beast.

The common objection of injury to canes by the roots of such trees growing on their borders, may be easily removed by digging a small trench between the canes and trees, which may intercept their roots, and oblige them to seek sustenance in the common road. Let it also be considered, besides the benefits above suggested, that the planter will thus beautify his estate to the resemblauce of a most sumptuous garden. And probably that very beauty might not only render the islands more healthful to the inhabitants, by preserving them from fevers kindled by the burning sun-beams, but also much more fruitful by making the weather more seasonable: for as, by cutting down all its woods, an hot country becomes more subject to excessive droughts; so, by replanting it in the manner above described, this inconvenience would probably be prevented.

Let then the planter be kind not only to his fellow-creatures but merciful to his beasts; giving them plenty and variety of wholesome food, clear water, cool shade, and a clean bed, bleeding them after a long course of hard labour, currying their hides from filth and ticks (A); affording them salt and other physic when necessary; protecting them from the flaying rope-lashes of a cruel driver (who needs no other instrument than a goad); porportioning their labour to their strength; and by every art rendering their work as easy as possible. The general management of planters is not, perhaps, more defective in any other respect than in this: for, by pairing the cattle unequally, and by the drivers ill conduct in writhing to the right and left, the poor creatures are fatigued by much needless labour. A horse ought therefore to be harnessed before them as a leader. This docile creature, by being led in a straight line, will soon learn to be an unerring guide, and the cattle will follow in the same direction with united strength, and consequently with more effect and less fatigue to each individual.

The Portuguese of Madeira, by their poverty and scantiness of pasture, breed the smallest kind of cattle; and yet one yoke of them will draw a much greater weight than a pair of our largest oxen, solely by an equal exertion of their joint strength. That equality or evenness of draught is preserved by boring gimblet holes through their horns, within two inches of the points, and running a thong of leather through those holes, so as to tie the horns of each pair at six inches distance from each other. By this ligature the pair of cattle are absolutely hindered from turning different ways, and draw in an even direction with united force. Thus it appears evidently from reason, as well as from experience, that the labour of our beasts may, by a little contrivance, be rendered more easy and effectual.

Of the Culture of various Soils.] In the British sugar-colonies there is as great a variety of soils as in any country of Europe; some naturally very rich or fruitful, yielding a luxuriant product with little labour or culture. This fruitful soil is of three kinds: a loose hazel mould mixed with sand, like that of St Christopher's, and is the best in the known world for producing sugar in great quantity, and of the best quality. The brick mould of Jamaica is somewhat of the same nature, and next in value; and then the various mixtures of mould and gravel, to be found in veins or plats over all the other islands. When any of these soils are exhausted of their fertility by long and injudicious culture, they may be restored by any kind of dung well rotted; for these (B) warm soils cannot bear hot unrotten dung, without being laid fallow for a considerable time after it. Another improvement is by sea-sand or sea-weed; or by digging in the cane-trash into steep lands, and by letting it lie to rot for some months. A third method is, by ploughing and laying it fallow; and the fourth method (the best of all), is by folding the fallows by sheep. But this can be practised only where there are extensive pastures; nor can the plough be employed where the soil abounds with large stones. In that case, however, the former method of digging in trash

(A) One pound of native sulphur, a quart of lamp-oil, and the like quantity of hog's-lard, intimately mixed and made into an ointment, is a cure for the mange, lice, &c.

(B) These soils, which are naturally loose and upon marle, Mr Martin calls *hot soils;* and these, he says, have been much injured in some of the islands by dung hastily made with marle: but if the sediment of lees were thrown into these pens, after being turned over, it would much improve the dung.

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trash will be nearly as effectual, though more expensive, by hand-labour or hoe-ploughing.

The next best soil for producing good sugar is a mould upon clay, which if shallow requires much culture and good labour, or its produce will be small in quantity, though of a strong grain and bright colour, so as to yield most profit to the refiner of any sugar, except that produced from an hazel or gravelly soil, as before-mentioned. All the black mould soils upon marle are generally fruitful, and will take any kind of dung; but yield not so strong or large-grained sugar. Marle, however, of a white, yellow, or blue colour, or rich mould from washes, or ashes of every kind, are excellent for every strong soil, as the chief ingredient in the compost of dung: either of them will do alone for stiff lands; but the yellow and chocolate marle are the most soapy, and the richest kind of manure (except fine mould) for all stiff lands. If these are well opened, pulverized by culture, and mixed with hot dung, or any kind of loose earth or marle, they will produce as plentifully as lighter soils: and all kinds of clay-soils, except that of a white colour, have these two advantages above the finest gravel soils, that they do not scorch soon by dry weather, and never grow weary of the same manure, as most other soils do.

The extraordinary hand-labour bestowed in making dung, may be saved by the art of caving, now in general use in England. Ten mules or horses, and two light tumbrels with broad wheels, and ten able negroes, may, by the common use of spades, shovels, and light mattocks or grubbing hoes, make more dung than 60 able negroes can do in the present methods.

If marle lies upon rising grounds, or in hillocks, as it often does, the pit is to be opened at the foot of the declivity; which being dug inwards, till the bank is three feet high, then it is to be *caved* thus. Dig an hollow space of 12 or 18 inches deep under the foot of the bank; then dig into each side of it another perpendicular cut of the same depth, and 18 inches wide from the top of the bank to the bottom: that being finished, make a small trench a foot or two from the brink of the bank; pour into it water till full; and when that is done, fill it again, till the water soaking downward makes the marle separate and fall down all at once. This may be repeated till the pit rises to 50 feet high; and then many hundreds of cart-loads of marle may be thrown down by four negroes in two hours; from whence it may be carted into cattle-pens, or laid out upon lands, as occasion requires. Five or six negroes with spades or shovels will keep two or three tumbrels employed, according to the distance of cartage: and thus as much dung may be made by ten negro men as will dung richly at least 70 or 80 acres of land every year, and laid out also with the assistance of cattle-carts: An improvement highly worthy every planter's consideration, when negroes and feeding them are so expensive; and this is no speculation, but has been confirmed by practice. In level lands, the same operation may be as effectual, provided the mouth of the pit be opened by gradual descent to any depth: but when marle is to be found on the sides of hills, the operation is less laborious for the horses. But if the surface of the marle-pits (as it often happens) be covered with clay or stiff soil, so that the water cannot quickly soak from the trench above; in that case, pieces of hard wood, made like piles, four feet long, and four inches square, pointed at one end, and secured at the other square head by an iron clamp, may be driven by heavy mauls into the trench, as so many wedges, which will make the caved part tumble down: but a skilful eye must watch the last operation, or the labourers may be buried or hurt.

But then clay soils that are level, and subject to be drowned, or to retain water in stagnated pools, can never be made fruitful by any kind of manure, without being first well drained: for water lying upon any soil will most certainly transform it to a stiff unfruitful clay; as appears evidently by the bogs of Ireland, the fens of Lincoln and Cambridgeshire, and even by the ponds of Barbadoes situated in the deepest and lightest black mould; for that fine soil being washed into those ponds, becomes the stiffest black clay, not fit even for an ingredient in dung, until it has been laid dry, and exposed to the sun for a whole year: but when these bogs and fens are well drained, they become the most fruitful soils. Natural clay the celebrated Boerhaave thinks the fattest of all soils; but then it must be opened by culture, marle, or sandy manures. It is hard to conjecture how the opinion prevailed in the British plantations, that sandy gut-mould was most unfit for clay-soils, as being the means of binding them to the compactness of brick; whereas it is proved, from long experience, to be one of the best means of opening clay soils, and rendering them abundantly fruitful. Brick is made of *clay alone;* no sand being used in it, farther than to sprinkle the board, on which it is moulded into shape. From repeated experience it appears, that a mixture of sand in gut-mould is the best of all manure for stiff and barren clay-lands; provided they be well drained, by throwing the whole soil into round ridges of 12 feet wide, with furrows of three feet wide between each ridge. And this is done with little more hand-labour than that of hoe-ploughing well in the common way. For if a piece of land be marked in lines at seven feet and a half distance from each other, and the labourers are set in to hoe-plough at the second line, hauling back each clod 12 inches; half the ridge, and near half the furrow, is made at the same time: and thus a piece of land may be round-ridged, and the furrows all made at once, by the common operation of hoe-ploughing, provided the digger drives his hoe up to the eye at every stroke. Hoe-ploughing in clay soils that have lain long under water, is indeed hard labour; but it will every year grow the lighter by being well drained by round-ridging: and in the meanwhile the labour may be rendered much more easy by the plough conducted by the lines above described. As therefore sandy mould is the best manure for stiff clay, so, by parity of reason, confirmed by long experience, stiff clay is the best manure for sandy or chaffy soils.

The method of round-ridging before described, is, by several years experience, found the most essential improvement of flat clayey soils: and yet there are some who will prefer speculation to ocular demonstration, fancying that all kinds of ridges will carry off the mould in heavy rains. The fact is otherwise in clay soils: and plain reason, without experience, vouches, that where great confluxes of water are divided into many small rills, the force is broken; and therefore less mould carried off the land. Another objection made to round-ridgeing is, that by digging much clay to form the sides of the

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the ridge, the ſoil is impoveriſhed: but this objection ſtands good only againſt thoſe ridges which are raiſed too high, and made too broad; but if land is ridged in the manner before directed, that is, 12 feet broad, and not above ſix or eight inches higher in the middle than at the ſides, the objection vaniſhes. Ridges were never propoſed for light ſoils or ſteep lands; and even in flat ſoils upon loam they ſhould be made with great caution, becauſe *loam melts away by water.* But there are poachy lands of a white clay, even upon ſmall deſcents, too retentive of water; theſe may certainly be improved much by ridges of 12 feet wide, as above deſcribed, without fear of waſhes.

But ſuppoſing, as the objection urges, that a little clay ſhould be turned up at the ſides of ſuch ridges, can it not be manured ſomewhat more than the other parts with marle or ſandy mould, ſo as to become equally good with any other part of the ſoil? And is not this well worth the labour, ſince round-ridging not only improves the ſoil by draining it to a ſurpriſing degree, but adds one-fifth part to the depth of the ſtaple? And will not a ridge made a little rounding, throw off the water much better than a flat ridge?

The general maxim of not burning cane-traſh) which may be called the *ſtubble of cane-lands)* upon any kind of ſoil, is ſurely a great miſtake; as may be evinced by obſerving the contrary practice of the beſt huſbandmen in England, where burn-baiting or baſtard burn-baiting, is found by experience an admirable method of fertilizing cold, ſtiff, or clayey lands. It muſt indeed be a conſtant practice, not only for the ſake of contributing to warm and divide the ſoil, but as the only effectual means of deſtroying pernicious inſects, and weeds of various kinds, ſuch as French weed, wild peaſe, and wild vines.

Soon after the diſuſe of burning traſh upon our lands in the iſlands, the blaſt made its firſt appearance with incredible devaſtation: to revive that practice therefore ſeems to be the moſt obvious means of expelling it. It may be preſumed that the diſuſe of burning traſh was founded upon the miſtaken notion of burn-baiting, which is turning up a thick ſod of very dry, light, and ſhallow ſoils, and burning the whole ſuperficies or ſtaple to aſhes. This practice the writers upon huſbandry condemn univerſally, and very juſtly: for though by this practice the land will produce two or three crops more plentifully than ever, yet the ſoil is blown away by the wind, and the ſubſtratum being generally an hungry gravel or chalk, can never be reſtored to fertility by the common arts of huſbandry. But ſurely this has no reſemblance to our ſuperficial burning of the little traſh we can ſpare from dung: and though this method of burn-baiting light and ſhallow ſoils be juſtly condemned, yet the beſt writers recommend that very practice in cold, moiſt, and heavy ſoils, as is obſerved above; and long experience juſtifies it.

Deep mould upon clay or loam being ſubject to the grub-worm (c), will not take any kind of dung, till perfectly rotten, except that of the ſheep-fold; which is the beſt manure for all kinds of light ſoils, and is of all others the leaſt expenſive, as not requiring hand-labour. But the uſe of the fold is impracticable in any iſland not abounding with large ſavannas or ſheep-paſtures, as in Jamaica.

Thoſe ſoils therefore which are ſubject to the grub, and muſt be fertilized by common dung, which is a proper neſt for the mother-beetle to depoſite its eggs, muſt be well impregnated with the brine of diſſolved ſalt, after the dung is firſt cut up; two large hogſheads of ſalt will make brine enough for a dung-pen of 50 feet ſquare.

This cure for the grub is a late diſcovery; and which has been attended with ſucceſs, ſo far as the experiment is made. But though it proves effectual to deſtroy that pernicious inſect in plant-canes, it probably will not be ſufficient to ſave rattoons, without a new application of ſalt in powder; becauſe the firſt brine muſt be waſhed away by the time when rattoons ſpring up.

The planter who would ſave his rattoons from the grub ought therefore to cut off the heads of his ſtools with ſharp hoes three inches below the ſurface of the ſoil, and then ſtrew an handful of ſalt round each ſtool, and cover it up to a level with fine mould taken from the edges.

In ſoils where there is no grub, and the planter wiſhes to have very good rattoons, let him, as ſoon as his canes are cut, draw all the traſh from the ſtools into the alternate ſpaces, if planted in that manner; or into the furrows, if his land be round-ridged; and then cut off the head of his ſtools with ſharp hoes, as above directed. Experience has ſhown the advantage of this practice, and reaſon demonſtrates the great benefit of the rattoon-ſprouts riſing from three inches below the ſurface, inſtead of ſuperficial ſhoots which come to nothing, and only ſtarve the ſtrong ſprouts. Beſides, the ſtubs which are left upon the ſtools after the canes are cut, canker, and rot the ſtools; which is one reaſon why good rattoons are uncommon in ſoils long cultivated. Yet it is the opinion of ſome, that by hoe-ploughing and even dunging rattoons, the produce might be as good plant-canes, which would ſave the labour of holing and planting ſo often as planters commonly do.

Fallowing is of incredible advantage to every ſoil, not only by being divided into the minuteſt parts, but alſo by imbibing thoſe vegetative powers with which the air is impregnated by the bountiful hand of Providence, whenever rain falls. What thoſe powers are has been explained under the articles AGRICULTURE and PLANT; and experience evinces, that the tender vegetables of the earth are invigorated more by the ſmalleſt ſhower of rain, than by all the water which human art can beſtow. Let it therefore be a conſtant maxim of the planter, never to plant his ground until the ſoil is well mellowed by fallowing, even though he beſtows upon it a due proportion of dung: we ſay a due proportion; for too much will force up rank canes, which never yield good ſugar; and though ſome advantage may be reaped from the rattoons,

(c) This pernicious inſect is moſt apt to engender in dung made from mill-traſh, which therefore never ought to be put into dung-compoſt or ſtill-ponds; but after being burnt, the aſhes will be as good as any other kind. Round-ridging, with manure of unwet aſhes, ſea-ſand, or lime, or dry marle, kills the grub.

toons, yet it will be found by experience not to compenſate the loſs by the plants. In ſtony or ſteep ſoils, where the plough cannot be uſed, or where a ſufficient ſtrength of cattle cannot be ſupported for that purpoſe, hand-labour or hoe-ploughing muſt be ſubſtituted: but even in that caſe, much labour may be ſaved by ſpreading the dung according to the Engliſh huſbandry, and digging it into the ſoil. To evince this truth, let any planter compute his negroes labour of diſtributing dung by baſkets, and by ſpreading it with dung-forks; and then judge for himſelf by one ſingle experiment which is the moſt profitable.

But if ſome planters are ſo devoted to the old cuſtom of diſtributing dung by baſkets inſtead of wheel-barrows in level ground, or hand-barrows in uneven land, by which three times the labour may be accompliſhed in the ſame time and by the ſame hands; let them at leaſt ſave much of their hand-labour, by the following method of laying out dung, before the diſtribution by baſkets.

In holing a piece of land, let a ſpace be left after 80 holes from the firſt interval, and then the like ſpace after 80 holes throughout the whole plat, which ſpaces muſt run exactly parallel to the intervals on the right and left of the holes. Into theſe ſpaces the dung may be carted, even before it be rotten (D), at the moſt leiſure times, and covered with mould or cane-traſh, to prevent exhalation; and in ſuch quantity as will ſuffice only to dung a row of 40 holes, from the point oppoſite to each ſide of it. In the intervals at each ſide of the cane-piece, which are parallel to thoſe ſpaces, there muſt be dung enough carted to manure a row of 40 holes, and covered in like manner.

By thus placing the dung or gut-mould, it is evident at the firſt ſight, that the fartheſt diſtance cannot be above 40 holes in diſtributing the dung: and in caſe it be not ſufficiently rotten for preſent uſe, it may be diſtributed even in dry weather, and covered by the bank; which will both prevent its ſpirit from exhalation, and occaſion it to rot ſooner, which is no ſmall advantage. Moreover, by being thus laid out at the moſt leiſure times, and covered with the banks, the dung will be more intimately mixed with the ſoil, and therefore continue to nouriſh the plant for a longer time than if laid as uſual at the bottom of the holes. A farther advantage of thus diſtributing the dung, and covering it, reſults from the more expeditious planting the land after a ſhort or ſudden ſhower: for the labour of covering the dung, and uncovering it when the land is planted, however it may appear in ſpeculation, is in practice a trifle; and beſides all the other advantages ariſing by the diſtribution of dung from the ſpaces above deſcribed, this is not the leaſt, that not a bank is trodden under foot. But it is evident, that by diſtributing the dung with baſkets in the preſent method, the ſoil is much trampled under foot; and by that means, the very end of hoe-ploughing, or looſening the ſoil, is much defeated. In like manner, by the preſent method of hoe-ploughing, the ſame ill effect is produced; for as the negroes hoe-plough or dig the ſoil directly forward, ſo they muſt neceſſarily tread the ground as faſt as they dig it: whereas by putting the labourers to dig ſidewiſe, no one puts a foot upon the ſoil after it is dug; and by lining the land before it is hoe-ploughed, each negro may have an equal ſhare to dig. The only difficulty of hoe-ploughing ſidewiſe is in firſt ſetting the negroes to that work; but it may be done without loſs of time when working in a contiguous field. Whether hoe-ploughing before or after the land be holed for canes is moſt eligible, experience muſt determine; but certainly both operations will be moſt effectual: and therefore it will be adviſable (E), firſt to plough the ſoil where the land will admit the plough; and where it will not, to hoe-plough it with or without dung, as requiſite; then let it lie fallow till perfectly mellowed; then hole and plant it; and inſtead of weeding in the uſual manner, let the weeds in all the ſpaces be dug into the ſoil: but as this is not to be done ſo well with the hoe, it is ſubmitted to future experience, whether the dexterous uſe of ſpades, as in England, will not anſwer the purpoſe much better, and with equal diſpatch. But whatever method is preferred, moſt certain it is, that by looſening the ſoil in all the ſpaces between the young canes after being come up, their fibres will more eaſily expand on every ſide, and acquire more nutrition to invigorate their growth. But where the planter grudges this labour, by thinking it needleſs in a rich looſe ſoil, he may diſpatch more weeding-work by the Dutch hoe than by any other; which being faſtened upon the end of a ſtick, is puſhed forward under the roots of the ſmall weeds, in ſuch a manner as to cut them up a little below the ſurface of the ſoil, and will do more execution at one ſhove than can be done at three ſtrokes of the common hoe: but there is yet another practice of the horſe-hoe plough, whereby all weeds growing in rows between beans and peaſe, are extirpated with incredible eaſe and expedition. It is a very ſimple machine, drawn by one or two horſes, conſiſting of a pair of low wheels turning upon a common axis; from whence two ſquare irons are let down at equal diſtances, and triangular hoes made at the ends, the points of the triangles being placed forward, and ſo fixed as to cut all weeds an inch below the ſurface, in the ſame manner as the Dutch garden-hoe above-mentioned. By this machine a man and a boy, with two horſes or mules, will clear perfectly all the ſpaces of a field of ten acres in two days, and may be of admirable uſe in all looſe and dry ſoils in the ſugar-iſlands: for while two horſes or mules draw in the ſpace before each other, the wheels paſs on the outſide of each row of canes, without doing the leaſt injury, while the plough-

(D) In order to make dung rot the ſooner, much labour is beſtowed in digging and turning it over by hoes: but two-thirds of that labour may be ſaved by the uſe of hay-knives; ſix of which, uſed dexterouſly, will cut up a pen in leſs time than 60 negroes can do by hoes: but hay-knives cannot be uſed where gritty mould is employed in pens.

(E) Deep and looſe ſoils may be ploughed with a ſmall ſtrength of cattle or mules: but ſtiff lands in hot climates require more ſtrength of cattle than can be maintained in the ſmall paſtures of the planters; for if thoſe ſtrong ſoils are either too wet or too dry (as is generally the caſe), ploughing is impracticable.

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plough-holder attends to his businefs. In ftiff foils which require draining, neither the horfe-hoe plough nor the Dutch hoe can be proper; or any other inftrument fo effectual as the fpade ufed in the manner above hinted, where the ftaple is deep.

But where the ftaple of land is fhallow, care muft be taken not to dig much below it, according to the univerfal opinion of all the beft writers, fupported by the experience of 100 years. Yet fome good planters are fallen into the contrary practice, and dig up ftiff clay far below the ftaple. This, Mr Martin fays, was done in his own lands, during his abfence, by injudicioufly ploughing below the ftaple; and fo injured the foil, that all the arts of culture for many years hardly retrieved its former fertility. Indeed, where the ftaple is fhallow, upon a fat clay, the turning up a little of it at a time, from the bottom of the cane-holes, and mixing it with rich hot dung, made of marle, or fandy mould, which may take off its cohefive quality, will in due time, and by long fallow, convert it into good foil: but if ftiff clay be turned up, without any fuch mixture, in large quantities, it will infallibly difappoint the operator's hopes: for though folid clay will moulder, by expofure, to a feeming fine earth, yet it will return to its primitive ftate very foon after being wet, and covered from the external air, if not divided, as above fuggefted.

After all, the common horfe-hoeing plough drawn by two mules in a line before each other, or the hand-hoe in common ufe, will anfwer the purpofe very well, where the lands are planted in Mr Tull's method; that is, where the fpaces are equal to the land planted, in the following manner.

Suppofe fix feet planted in two rows of canes, and fix feet of land left as a fpace unplanted; and fo a whole piece of land, planted in alternate double rows (F), with equal fpaces, may be hoe-ploughed with eafe, as before hinted; and that at any time during the growth of canes, when it is moft convenient to the planter, which is a confiderable advantage; and yet it is the leaft of all attending this method of culture: for, by leaving thefe fpaces, the canes will have both more air and fun: by hoe-ploughing them, the roots of each double row will have large room for expanfion, and confequently, by gaining more nutriment, will grow more luxuriantly: by thefe fpaces the canes may be cleaned from the blaft with much more eafe and convenience: and will ferve as proper beds to plant great corn, without the leaft injury to the canes; as well as to contain the trafh taken off the land, where, by rotting, and being hoe-ploughed into the foil, it will wonderfully enrich it, and will fit it to be planted immediately after the canes in the neighbouring double rows are cut down. Befides all thefe admirable advantages of planting the land in alternate double rows with equal fpaces, the canes, when at full age, may be eafily ftripped of their trafh, and by that means the juice rendered fo mature as to yield double the produce, and much better fugars than unftripped canes. This method of culture may be recommended for all kinds of foil: for as by this practice the rank luxuriant canes will be more matured, fo the poor foils will be rendered more fruitful; and as the roots of the canes which expand into thefe fpaces will be kept moift by being covered with rotten trafh, fo they muft bear dry weather much longer in the burning foils. In thofe low lands which require draining by furrows, the alternate double rows and fpaces muft be made crofs the ridges; by which means thofe fpaces, being hoe-ploughed from the centre to the fides, will be always preferved in a proper ftate of roundnefs. By this method of planting, the canes may be fo well ripened as to yield double the quantity of fugar of canes planted in the clofe manner; which faves half the labour of cartage, half the time of grinding and boiling, and half the fuel, befides yielding finer fugar.

Yet, how well foever the method of planting in fingle or double alternate rows has fucceeded in the loofe and ftiff foils, experience has fhown that it is a wrong practice in ftiff lands that are thrown into round or flat ridges: for thefe being moft apt to crack, the fun-beams penetrate foon to the cane-roots, ftop their growth, and have an ill influence upon the fugar. It is therefore advifable to plant fuch lands full, but in large holes, of 4 feet, by 5 feet towards the banks: after the plant-canes are cut, to dig out one, and leave two rows ftanding, hoe-ploughing the fpaces after turning all the trafh into furrows till almoft rotten: for if the trafh is drawn upon the hoe-ploughed fpaces, they will hardly ever moulder, at leaft not till the trafh is quite rotten. This is an infallible proof from experience of how little advantage trafh is to the foil, unlefs it be in great droughts, to keep out the intenfe fun-beams: for, in all other refpects, it prevents that joint operation of the fun and air in mouldering and fructifying the foil, as has been proved by repeated experiments.

But in flat ftiff foils that are properly drained by round-ridging, no culture prevents cracking fo effectually as hoe-ploughing into them a qantity of loofe marle, of which that of a chocolate or of a yellow colour is beft; and it will be ftill much better, by lying upon the land, in fmall heaps, or in cane-holes, for fome time, to imbibe the vegetative powers of the air before it is intimately mixed with the foil.

As to the manner of planting canes, the general practice of allowing four feet by five to an hole, and two frefh (G) plants, is found by common experience to be right and good in alternate rows. But the following precautions are neceffary to be obferved. Firft, let all the cane-rows run eaft and weft, that the trade-wind may pafs freely through them; becaufe air and funfhine are as conducive to the growth and maturation of fugar-canes as of any other vegetable. Secondly, let not any acceffion of mould be drawn into hills round the young canes, except where water ftagnates (H); becaufe the fibres which run horizontally, and near the furface, are much

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(F) In ftiff lands, the fingle alternate rows of four feet diftance, as preventive of much labour in weeding, are found beft; and alfo yield more fugar by the acre; and are lefs apt to be affected by drought.

(G) It is an odd fancy that ftale plants grow beft, when both reafon and experience vouch that the moft fucculent plants are beft: one good plant in the centre of a large hole is fufficient when the land is full holed.

(H) The ftagnation of water in pools (ufual in ftiff level lands) is the moft injurious circumftance attending it; for much broken and ſpoiled by that practice. Thirdly, let the ſugar-canes be cut at their full maturity: which, in a dry looſe ſoil, is generally at the end of 14 or 15 months after being planted; but in cold clay-ſoils, not till 16 or 17 months. Fourthly, as the cane-rows run eaſt and weſt in as proper a direction as poſſible for cartage to the ſugar work, ſo canes muſt be cut the contrary way if the planter expects any great produce from his rattoons: for by beginning to cut canes at the part of his field moſt remote from the works, the carts cannot often paſs over the ſame tract, and conſequently the cane-ſtools cannot be injured, more eſpecially if he takes due care to cut the canes very cloſe to their roots; for, by leaving a long ſtub (which muſt periſh) the cane-ſtools are much injured. It may be objected to the practice of cutting canes tranſverſely to the rows, that the negroes labour will not be ſo equally divided: but let every man conſider both ſides of the queſtion, and be determined by his own experience; and then he will be convinced, that it matters very little which way he cuts ſtraight ſtanding canes; but in caſes where the ſugar-canes lean, or are lodged by preceding high winds, it is a point of great importance to place the labourers ſo as to cut the canes firſt at the roots, and then, drawing them, cut off the tops: for thus by two ſtrokes each cane will be cut; and twice the quantity cut in the ſame time, and by the ſame hands, more than by cutting in any other direction. In round-ridged land, it is proper to cut canes in the ſame direction of the ridges, throwing the tops and traſh into the furrows to render the cartage eaſy, and to preſerve the ridges in their proper form.

It is almoſt needleſs to ſuggeſt the expediency of planning the cane-pieces of a plantation in exact ſquares, ſo that the intervals may interſect at right angles; ſince ſuch regularity is not only more beautiful, more ſafe in caſe of accidental fires, and a better diſpoſition of the whole for dividing and planting one third or fourth part of a plantation every year, but alſo much eaſier guarded by a few watchmen: for one of theſe walking in a line from eaſt to weſt, and the other from north to ſouth, look through every avenue, where the moſt ſubtle thief cannot eſcape the watchful eye. And if the intervals ſurrounding the boundary of a regular plantation be made 24 feet wide, the proprietor will receive ample recompenſe for ſo much land, by the ſecurity of his canes from fires kindled in the neighbourhood, and by planting all that land in plantain-trees, which may at once yield food and ſhade to the watchmen, who by that means can have no excuſe for abſence from their proper ſtations. But as fuel grows very ſcarce in moſt of our iſlands, it is alſo expedient to plant a logwood or flower-fence in all the boundaries of every plantation, which, being cut every year, will furniſh good ſtore of faggots. Logwood makes the ſtrongeſt and quickeſt of all fences, and agrees with every ſoil: the cuttings make excellent oven-fuel.

So much for the general operations of planterſhip, according to the approved directions of Mr Martin. For the particular cultivation of the ſugar-canes, the extraction of the ſugar, and the diſtillation of rum, ſee the articles SUGAR, and RUM.

PLANTING, in *Agriculture* and *Gardening*, is ſetting a tree or plant, taken from its proper place, in a new hole or pit; throwing freſh earth over its root, and filling up the hole to the level of the ſurface of the ground.

The firſt thing in planting is to prepare the ground before the trees or plants are taken out of the earth, that they may remain out of the ground as ſhort a time as poſſible; and the next is, to take up the trees or plants, in order to their being tranſplanted. In taking up the trees, carefully dig away the earth round the roots, ſo as to come at their ſeveral parts to cut them off; for if they are torn out of the ground without care, the roots will be broken and bruiſed, to the great injury of the trees. When you have taken them up, the next thing is to prepare them for planting by pruning the roots and heads. And firſt, as to the roots; all the ſmall fibres are to be cut off, as near to the place from whence they are produced as may be, except they are to be replanted immediately after they are taken up. Then prune off all the bruiſed or broken roots, all ſuch as are irregular and croſs each other, and all downright roots, eſpecially in fruit-trees: ſhorten the larger roots in proportion to the age, the ſtrength, and nature of the tree; obſerving that the walnut, mulberry, and ſome other tender-rooted kinds ſhould not be pruned ſo cloſe as the more hardy ſorts of fruit and foreſt trees: in young fruit-trees, ſuch as pears, apples, plums, peaches, &c. that are one year old from the time of their budding or grafting, the roots may be left only about eight or nine inches long; but in older trees, they muſt be left of a much greater length: but this is only to be underſtood of the larger roots; for the ſmall ones muſt be chiefly cut quite out, or pruned very ſhort. The next thing is the pruning of their heads, which muſt be differently performed in different trees; and the deſign of the trees muſt alſo be conſidered. Thus, if they are deſigned for walls or eſpaliers, it is beſt to plant them with the greateſt part of their heads, which ſhould remain on till they begin to ſhoot in the ſpring, when they muſt be cut down to five or ſix eyes, at the ſame time taking care not to diſturb the roots. But if the trees are deſigned for ſtandards, you ſhould prune off all the ſmall branches cloſe to the place where they are produced, as alſo the irregular ones which croſs each other; and after having diſplaced theſe branches, you ſhould alſo cut off all ſuch parts of branches as have by any accident been broken or wounded; but by no means cut off the main leading ſhoots which are neceſſary to attract the ſap from the root, and thereby promote the growth of the tree. Having thus prepared the trees for planting, you muſt now proceed to place them in the earth: but firſt, if the trees have been long out of the ground, ſo that the fibres of the roots are dried, place them eight or ten hours in water, before they are planted, with their heads erect, and the roots only immerſed therein; which

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for that, by long duration, will convert the fineſt mould into ſtiff clay. The proprietor of ſuch a ſoil muſt therefore grudge no labour to drain it well; and yet by ſuch eaſy gradation as to prevent the mould from being waſhed away by great floods, in caſe the under ſtratum be a loam.

which will ſwell the dried veſſels of the roots, and prepare them to imbibe nouriſhment from the earth. In planting them, great regard ſhould be had to the nature of the ſoil: for if that be cold and moiſt, the trees ſhould be planted very ſhallow; and if it be a hard rock or gravel, it will be better to raiſe a hill of earth where each tree is to be planted, than to dig into the rock or gravel, and fill it up with earth, as is too often practiſed, by which means the trees are planted as it were in a tub, and have but little room to extend their roots. The next thing to be obſerved is, to place the trees in the hole in ſuch a manner that the roots may be about the ſame depth in the ground as before they were taken up; then break the earth fine with a ſpade, and ſcatter it into the hole, ſo that it may fall in between every root, that there may be no hollowneſs in the earth: then having filled up the hole, gently tread down the earth with your feet, but do not make it too hard; which is a great fault, eſpecially if the ground be ſtrong or wet. Having thus planted the trees, they ſhould be faſtened to ſtakes driven into the ground to prevent their being diſplaced by the wind, and ſome mulch laid upon the ſurface of the ground about their roots; as to ſuch as are planted againſt walls, their roots ſhould be placed about five or ſix inches from the wall, to which their heads ſhould by nailed to prevent their being blown up by the wind. The ſeaſons for planting are various, according to the different ſorts of trees, or the ſoil in which they are planted. For the trees whoſe leaves fall off in winter, the beſt time is the beginning of October, provided the ſoil be dry; but if it be a very wet ſoil, it is better to defer it till the latter end of February, or the beginning of March: and for many kinds of evergreens, the beginning of April is by far the beſt ſeaſon; though they may be ſafely removed at midſummer, provided they are not to be carried very far; but ſhould always make choice of a cloudy wet ſeaſon.

In the ſecond volume of the papers, &c. of the Bath Society there is a letter on planting waſte grounds. The gentleman who writes it informs us, that in the county of Norfolk, where he reſides, there were about 60 or 70 years ago vaſt tracts of uncultivated ground, which were then thought totally barren. "The weſtern parts of it (ſays he) abounded with ſand of ſo light a texture, that they were carried about by every wind; and in many places the ſands were ſo looſe that no graſs could grow upon them. Art and induſtry, however, have now ſo altered the face of this once Arabian deſert, that it wears a very different appearance. Moſt of theſe tracts are either planted or rendered very good corn-land and ſheep-walks.

"About 30 years ſince, the ſides of many of our little ſand-hills were ſown with the ſeeds of French furze, and when a wet ſeaſon followed, they ſucceeded very well, and grew ſo faſt, that once in three or four years they are cut for fuel, and ſell at a good price at Thetford, Brandon, Harling, Swaffham, and places adjacent. This excited ſome public-ſpirited gentlemen, among whom was the late Mr Buxton of Shadwell-Lodge, near Thetford, to attempt the planting of Scotch and ſpruce firs, and other hardy foreſt-trees. At firſt they found ſome difficulty from the extreme looſeneſs of the ſand. But as there is in all this part of the country fine white and yellow marle, at about three feet depth below the ſand, they very judiciouſly thought that incorporating it with the ſand in the holes where their young trees were planted, would inſure ſucceſs; nor were they diſappointed. The method ſucceeded beyond expectation; the plantations throve exceedingly, and the roots ſoon reached below the ſand, after which they were out of danger. This excited them to further attempts.

"On the ſpots where they intended to raiſe new plantations from ſeeds and acorns, they laid on a thick coat of marle and clay, which after being rough ſpread, and lying a winter in that ſtate, was made fine, and ploughed in juſt before planting. By theſe means the ſoil became fixed, and in a little time covered with graſs and herbage; ſo that there are now vaſt plantations of firs, oak, and foreſt-trees, in the moſt healthy and vigorous ſtate, where within my memory ten acres of land would not maintain a ſingle ſheep three months.

"But the benefit of plantations, whether of ſhrubs, copſe, or trees, is not confined to the immediate advantage, or even the future value of the wood. By annually ſhedding a great number of leaves, which the winds diſperſe, and the rains waſh into the ſoil, it is conſiderably improved; and whenever ſuch copſes have been ſtubbed up, the ground (however unfruitful before planting) has thereby been ſo enriched as to bear excellent crops for many years, without the additional help of manure. How much land-owners are intereſted in planting waſte or barren ſpots I need not mention; and nothing but a degree of indolence or ignorance unpardonable in this enlightened age could induce them to neglect it.

"Nature has furniſhed us with plants, trees, and ſhrubs, adapted to almoſt every ſoil and ſituation; and as the laws of vegetation are now much better underſtood than formerly, it is a reproach to thoſe whoſe practice does not keep pace with their knowledge in making the beſt uſe of her bounty. Let no man repine and ſay *the land is barren;* for thoſe ſpots which appear to be ſo, owe that appearance to human negligence. Induſtry and art might ſoon render an eighth part of this kingdom nearly as valuable as the reſt, which now remains in a ſtate unprofitable to the owners, and diſgraceful to the community."

Reverſe PLANTING, a method of planting in which the natural poſition of the plant or ſhoot is inverted; the branches being ſet into the earth, and the root reared into the air. Dr Agricola mentions this monſtrous method of planting, which he found to ſucceed very well in moſt or all ſorts of fruit-trees, timber-trees, &c. Bradley affirms, that he has ſeen a lime-tree in Holland growing with its firſt roots in the air, which had ſhot out branches in great plenty, at the ſame time that its firſt branches produced roots and fed the tree. Mr Fairchild of Hoxton has practiſed the ſame with us, and gives the following directions for performing it: Make choice of a young tree of one ſhoot, of alder, elm, willow, or any other tree that eaſily takes root by laying; bend the ſhoot gently down into the earth, and ſo let it remain until it has taken root. Then dig about the firſt root, and raiſe it gently out of the ground, till the ſtem be nearly upright, and ſtake it up. Then prune the roots, now erected in the air, from the bruiſes and wounds they received in being dug up; and anoint the pruned parts with a compoſition of two ounces of turpentine, four ounces of tallow, and four ounces of bees wax, melted together, and applied pretty warm. Afterwards

terwards prune off all the buds or ſhoots that are upon the ſtem, and dreſs the wounds with the ſame compoſition, to prevent any collateral ſhootings, that might ſpoil the beauty of the ſtem.

PLANUDES, Maximus, a Greek monk of Conſtantinople, towards the end of the 14th century, who publiſhed a collection of epigrams intitled *Anthologia;* a Greek tranſlation of Ovid's Metamorphoſes; a Life of Æſop, which is rather a romance than a hiſtory; and ſome other works. We know nothing more of him, than that he ſuffered ſome perſecution on account of his attachment to the Latin church.

PLASHING *of* Hedges, is an operation thought by ſome perſons to promote the growth and continuance of old hedges; but whether the fact be ſo or not will admit of ſome diſpute. See Hedges.

It is performed in this manner: The old ſtubs muſt be cut off, &c. within two or three inches of the ground; and the beſt and longeſt of the middle-ſized ſhoots muſt be left to lay down. Some of the ſtrongeſt of theſe muſt alſo be left to anſwer the purpoſe of ſtakes. Theſe are to be cut off to the height at which the hedge is intended to be left; and they are to ſtand at ten feet diſtance one from another: when there are not proper ſhoots for theſe at the due diſtances, their places muſt be ſupplied with common ſtakes of dead wood. The hedge is to be firſt thinned, by cutting away all but thoſe ſhoots which are intended to be uſed either as ſtakes, or the other work of the plaſhing: the ditch is to be cleaned out with the ſpade; and it muſt be now dug as at firſt, with ſloping ſides each way; and when there is any cavity on the bank on which the hedge grows, or the earth has been waſhed away from the roots of the ſhrubs, it is to be made good by facing it, as they expreſs it, with the mould dug from the upper part of the ditch: all the reſt of the earth dug out of the ditch is to be laid upon the top of the bank: and the owner ſhould look carefully into it that this be done; for the workmen, to ſpare themſelves trouble, are apt to throw as much as they can upon the face of the bank; which being by this means overloaded, is ſoon waſhed off into the ditch again, and a very great part of the work undone; whereas what is laid on the top of the bank always remains there, and makes a good fence of an indifferent hedge.

In the plaſhing the quick, two extremes are to be avoided; theſe are, the laying it too low, and the laying it too thick. The latter makes the ſap run all into the ſhoots, and leaves the plaſhes without ſufficient nouriſhment; which, with the thickneſs of the hedge, finally kills them. The other extreme of laying them too high, is equally to be avoided; for this carries up all the nouriſhment into the plaſhes, and ſo makes the ſhoots ſmall and weak at the bottom, and conſequently the hedge thin. This is a common error in the north of England. The beſt hedges made anywhere in England are thoſe in Hertfordſhire; for they are plaſhed in a middle way between the two extremes, and the cattle are by that prevented both from cropping the young ſhoots, and from going through; and a new and vigorous hedge ſoon forms itſelf.

When the ſhoot is bent down that is intended to be plaſhed, it muſt be cut half way through with the bill: the cut muſt be given ſloping, ſomewhat downwards, and then it is to be wound about the ſtakes, and after this its ſuperfluous branches are to be cut off as they ſtand out at the ſides of the hedge. If for the firſt year or two, the field where a new hedge is made can be ploughed, it will thrive the better for it; but if the ſtubs are very old, it is beſt to cut them quite down, and to ſecure them with good dead hedges on both ſides, till the ſhoots are grown up from them ſtrong enough to plaſh; and wherever void ſpaces are ſeen, new ſets are to be planted to fill them up. A new hedge raiſed from ſets in the common way, generally requires plaſhing in about eight or nine years after.

PLASSEY, is a grove near the city of Muxadab in India, famous for a battle fought between the Engliſh under Lord Clive, and the native Hindoos under the nabob Surajah Dowlah. The Britiſh army conſiſted of about 3200 men, of whom the Europeans did not exceed 900; while that of the nabob conſiſted of 50,000 foot, and 18,000 horſe. Notwithſtanding this great diſproportion, however, Lord Clive effectually routed the nabob and his forces, with the loſs of three Europeans and 26 Seapoys killed, and five Europeans and 40 Seapoys wounded. The nabob's loſs was eſtimated at about 200 men, beſides oxen and elephants. See Clive.

PLASTER, or Emplaster, in *Pharmacy*, an external application of a harder conſiſtence than an ointment; to be ſpread, according to the different circumſtances of the wound, place, or patient, either upon linen or leather.

Plaster, or *Plaiſter*, in building, a compoſition of lime, ſometimes with ſand, &c. to parget, or cover the nudities of a building. See Pargeting and Stucco.

Plaster of Paris, a preparation of ſeveral ſpecies of gypſum dug near Mount Martre, a village in the neighbourhood of Paris; whence the name. See Alabaster, Gypsum, and Sulphate of Lime, under Chemistry.

The beſt ſort is hard, white, ſhining, and marbly; known by the name of *plaſter-ſtone* or *parget of Mount Martre*. It will neither give fire with ſteel, nor ferment with aquafortis; but very freely and readily calcines in the fire into a fine plaſter, the uſe of which in building and caſting ſtatues is well known.

The method of repreſenting a face truly in plaſter of Paris is this: The perſon, whoſe figure is deſigned, is laid on his back, with any convenient thing to keep off the hair. Into each noſtril is conveyed a conical piece of ſtiff paper, open at both ends, to allow of reſpiration. Theſe tubes being anointed with oil, are ſupported by the hand of an aſſiſtant; then the face is lightly oiled over, and the eyes being kept ſhut, alabaſter freſh calcined, and tempered to a thinniſh conſiſtence with water, is by ſpoonfuls nimbly thrown all over the face, till it lies near the thickneſs of an inch. This matter grows ſenſibly hot, and in about a quarter of an hour hardens into a kind of ſtony concretion; which being gently taken off, repreſents, on its concave ſurface, the minuteſt part of the original face. In this a head of good clay may be moulded, and therein the eyes are to be opened, and other neceſſary amendments made. This ſecond face being anointed with oil, a ſecond mould of calcined alabaſter is made, conſiſting of two parts joined lengthwiſe

Plaster.

lengthwiſe along the ridge of the noſe; and herein may be caſt, with the ſame matter, a face extremely like the original.

If finely powdered alabaſter, or plaſter of Paris, be put into a baſon over a fire, it will, when hot, aſſume the appearance of a fluid, by rolling in waves, yielding to the touch, ſteaming, &c. all which properties it again loſes on the departure of the heat; and being thrown upon paper, will not at all wet it, but immediately diſcover itſelf to be as motionleſs as before it was ſet over the fire; whereby it appears, that a heap of ſuch little bodies, as are neither ſpherical nor otherwiſe regularly ſhaped, nor ſmall enough to be below the diſcernment of the eye, may, without fuſion, be made fluid, barely by a ſufficiently ſtrong and various agitation of the particles which compoſe it; and moreover loſe its fluidity immediately upon the ceſſation thereof.

Two or three ſpoonfuls of burnt alabaſter, mixed up thin with water, in a ſhort time coagulate, at the bottom of a veſſel full of water, into a hard lump, notwithſtanding the water that ſurrounded it. Artificers obſerve, that the coagulating property of burnt alabaſter will be very much impaired or loſt, if the powder be kept too long, eſpecially if in the open air, before it is made uſe of; and when it hath been once tempered with water, and ſuffered to grow hard, they cannot, by any burning or powdering of it again, make it ſerviceable for their purpoſe as before.

This matter, when wrought into veſſels, &c. is ſtill of ſo looſe and ſpongy a texture, that the air has eaſy paſſage through it. Mr Boyle gives an account, among his experiments with the air-pump, of his preparing a tube of this plaſter, cloſed at one end and open at the other; and on applying the open end to the cement, as is uſually done with the receivers, it was found utterly impoſſible to exhauſt all the air out of it; for freſh air from without preſſed in as faſt as the other, or internal air, was exhauſted, though the ſides of the tube were of a conſiderable thickneſs. A tube of iron was then put on the engine; ſo that being filled with water, the tube of plaſter of Paris was covered with it; and on uſing the pump, it was immediately ſeen, that the water paſſed through into it as eaſily as the air had done, when that was the ambient fluid. After this, trying it with Venice turpentine inſtead of water, the thing ſucceeded very well; and the tube might be perfectly exhauſted, and would remain in that ſtate ſeveral hours. After this, on pouring ſome hot oil upon the turpentine, the caſe was much altered; for the turpentine melting with this, that became a thinner fluid, and in this ſtate capable of paſſing like water into the pores of the plaſter. On taking away the tube after this, it was remarkable that the turpentine, which had pervaded and filled its pores, rendered it tranſparent, in the manner that water gives tranſparency to that ſingular ſtone called *oculus mundi*. In this manner, the weight of air, under proper management, will be capable of making ſeveral ſorts of glues penetrate plaſter of Paris; and not only this, but baked earth, wood, and all other bodies, porous enough to admit water on this occaſion.

Plaſter of Paris is uſed as a manure in Penſylvania, as we find mentioned in a letter from a gentleman in that country inſerted in the 5th volume of the Bath Society Papers, and which we ſhall inſert here for the ſatisfaction and information of our agricultural readers. "The beſt kind is imported from hills in the vicinity of Paris: it is brought down the Seine, and exported from Havre de Grace. I am informed there are large beds of it in the bay of Fundy, ſome of which I have ſeen nearly as good as that from France; nevertheleſs ſeveral cargoes brought from thence to Philadelphia have been uſed without effect. It is probable this was taken from the top of the ground, and by the influence of the ſun and atmoſphere diſpoſſeſſed of the qualities neceſſary for the purpoſes of vegetation. The lumps compoſed of flat ſhining ſpecula are preferred to thoſe which are formed of round particles like ſand: the ſimple method of finding out the quality is to pulverize ſome, and put it dry into an iron pot over the fire, when that which is good will ſoon boil, and great quantities of the fixed air eſcape by ebullition. It is pulverized by firſt putting it in a ſtamping-mill. The finer its pulverization the better, as it will thereby be more generally diffuſed.

"It is beſt to ſow it in a wet day. The moſt approved quantity for graſs is ſix buſhels per acre. No art is required in ſowing it more than making the diſtribution as equal as poſſible on the ſward of graſs. It operates altogether as a top manure, and therefore ſhould not be put on in the ſpring until the principal froſts are over and vegetation hath begun. The general time for ſowing with us is in April, May, June, July, Auguſt, and even as late as September. Its effects will generally appear in 10 or 15 days; after which the growth of the graſs will be ſo great as to produce a large burden at the end of ſix weeks after ſowing.

"It muſt be ſown on dry land, not ſubject to be overflown. I have ſown it on ſand, loam, and clay, and it is difficult to ſay on which it has beſt anſwered, although the effect is ſooner viſible on ſand. It has been uſed as a manure in this ſtate for upwards of 12 years. Its duration may, from the beſt information I can collect, be eſtimated from 7 to 12 years; for, like other manure, its continuance very much depends on the nature of the ſoil on which it is placed.

"One of my neighbours ſowed ſome of his graſs ground ſix years ago, another four years ago; a great part of my own farm was ſown in May 1788. We regularly mow two crops, and paſture in autumn; no appearance of failure, the preſent crop being full as good as any preceding. I have this ſeaſon mowed 50 acres of red clover, timothy graſs, white clover, &c. which was plaſtered laſt May, July, and September: many who ſaw the graſs eſtimated the produce at two tons per acre, but I calculate the two crops at three tons. Several ſtripes were left in the different fields without plaſter; theſe were in a meaſure unproductive, being ſcarcely worth mowing. In April 1788, I covered a piece of graſs land upwards of two inches thick with barn manure; in the ſame worn-out field I ſowed plaſter, to contraſt it with the dung. I mowed the dunged and plaſtered land twice laſt year and once this; in every crop the plaſter has produced the moſt. You will remember, in all experiments with clover, to mix about one-third timothy graſs ſeed; it is of great advantage in ſerving as a ſupport for the clover; it very much facilitates the curing of clover, and when cured is a ſuperior fodder. The plaſter operates equally as well on the other graſſes as on clover. Its effect is ſaid to be good on wheat, if ſown in the ſpring; but I cannot ſay this from experience. On Indian corn I know its operation to to be great; we uſe it at the rate of a table ſpoonful for a hill, put in immediately after dreſſing.

"From ſome accurate experiments laſt year made and reported to our Agricultural Society, it appears that nine buſhels of additional corn per acre were produced by this method of uſing plaſter."

PLASTERING. See PARGETTING.

PLASTIC, denotes a thing endowed with a formative power, or a faculty of forming or faſhioning a maſs of matter after the likeneſs of a living being.

PLASTIC-Nature, a certain power by which, as an inſtrument, many philoſophers, both ancient and modern, have ſuppoſed the great motions in the corporeal world, and the various proceſſes of generation and corruption, to be perpetually carried on.

Among the philoſophers of Greece, ſuch a power was almoſt univerſally admitted. It ſeems, indeed, to have been rejected only by the followers of Democritus and Epicurus, who talk as if they had thought gravity eſſential to matter, and the *fortuitous* motion of atoms, which they held to have been from eternity, the ſource not only of all the *regular* motions in the univerſe, but alſo of the *organization* of all corporeal ſyſtems, and even of *ſenſation* and *intellection*, in brutes and in men. It is needleſs to ſay, that thoſe men, whatever they might profeſs, were in reality atheiſts; and Democritus, it is univerſally known, avowed his atheiſm.

The greater part of the philoſophers who held the exiſtence of a plaſtic nature, conſidered it not as an *agent* in the ſtrict ſenſe of the word, but merely as an inſtrument in the hand of the Deity; though even among them there were ſome who held no ſuperior power, and were of courſe as groſs atheiſts as Democritus himſelf. Such was *Strato* of Lampſacus. This man was originally of the peripatetic ſchool, over which he preſided many years, with no ſmall degree of reputation for learning and eloquence. He was the firſt and chief aſſertor of what has been termed *Hylozoic atheiſm*; a ſyſtem which admits of no power ſuperior to a certain *natural* or *plaſtic life*, *eſſential*, *ingenerable*, and *incorruptible*, inherent in matter, but without ſenſe and conſciouſneſs. That ſuch was his doctrine we learn from Cicero, who makes *Velleius* the Epicurean ſay, "Nec audiendus *Strato* qui *Phyſicus* appellatur, qui omnem vim divinam in Natura ſitam eſſe cenſet, quæ cauſas gignendi, augendi, minuendive habeat, ſed careat omni ſenſu *." That Strato in admitting this plaſtic principle, differed widely from Democritus, is apparent from the following account of him by the ſame author: *Strato Lampſacenus* negat opera deorum ſe uti ad fabricandum mundum, quæcunque ſint docet omnia eſſe effecta *naturæ*, nec ut ille, qui aſperis, et levibus, et hamatis uncinatiſque corporibus concreta hæc eſſe dicat, interjecta inani; ſomnia cenſet hæc eſſe *Democriti*, non docentis ſed optantis †."

* *De Natura Deorum*, lib. i. cap. 13.

† *Acad. Quæſt.* lib. iv. cap. 38.

That the rough and ſmooth, and hooked and crooked, atoms of Democritus, were indeed dreams and dotages, is a poſition which no man will controvert; but ſurely Strato was himſelf as great a dreamer when he made ſenſation and intelligence reſult from a certain plaſtic or ſpermatic life in matter, which is itſelf devoid of ſenſe and conſciouſneſs. It is, indeed, inconceivable, to uſe the emphatic language of Cudworth, "how any one in his ſenſes ſhould admit ſuch a monſtrous paradox as this, that every atom of duſt has in itſelf as much wiſdom as the greateſt politician and moſt profound philoſopher, and yet is neither conſcious nor intelligent!" It is to be obſerved of Strato likewiſe, that though he attributed a certain kind of life to matter, he by no means allowed of one common life as ruling over the whole material univerſe. He ſuppoſed the ſeveral parts of matter to have ſo many ſeveral plaſtic lives of their own, and ſeems ‡ to have attributed ſomething to chance in the production and preſervation of the mundane ſyſtem.

‡ *Cud. Int. Syſt. ed. Moſheim*, lib. i. cap. 3.

In denying the exiſtence of a God, perpetually directing his plaſtic principle, and in ſuppoſing as many of theſe principles as there are atoms of matter, Strato deviated far from the doctrine of Ariſtotle. The great founder of the peripatetic ſchool, as well as his apoſtate diſciple, taught that mundane things are not effected by fortuitous mechaniſm, but by ſuch a *nature* as acts regularly and artificially for *ends*; yet he never conſiders this *nature* as the higheſt principle, or ſupreme *Numen*, but as ſubordinate to a perfect mind or intellect; and he expreſsly affirms, that "*mind*, together with *nature*, formed or faſhioned this univerſe." He evidently conſiders mind as the principal and intelligent agent, and nature as the ſubſervient and executive inſtrument. Indeed, we are ſtrongly inclined to adopt the opinion of the learned Moſheim, who thinks that by nature Ariſtotle meant nothing more than that θερμοτης ψυχικη, or *animal heat*, to which he attributes immortality, and of which he expreſsly ſays § that all things are full. Be this as it may, he always joins God and nature together, and affirms that they do nothing in vain. The ſame doctrine was taught before him by Plato, who affirms that "nature, together with reaſon, and according to it, orders all things." It muſt not, however, be concealed, that Plato ſeems to have attributed intelligence to the principle by which he ſuppoſed the world to be animated; for Chalcidius, commenting on the Timæus ‡, thus expreſſes himſelf: "Hæc eſt illa *rationabilis* anima mundi, quæ gemina juxta meliorem naturam veneratione tutelam præbet inferioribus, divinis diſpoſitionibus obſequens, providentiam nativis impertiens, æternorum ſimilitudine propter cognationem beata."—Apuleius too, tells us ||, "Illam cœleſtem animam, fontem animarum omnium, optimam virtutem eſſe genetricem, ſubſerviri etiam Fabricatori Deo, et præſto eſſe ad omnia inventa ejus." *Plato pronunciat.*

§ *De Generatione Animal.* lib. iii. cap. 11.

‡ Sect. 53.

|| *De Dogmate Platonis.*

The doctrine of Plato has been adopted by many moderns of great eminence both for genius and for learning. The celebrated Berkeley biſhop of Cloyne, after giving the view of Plato's *anima mundi*, which the reader will find in our article MOTION, N° 10, thus recommends the ſtudy of his philoſophy *: "If that philoſopher himſelf was not read only, but ſtudied alſo with care, and made his own interpreter, I believe the prejudice that now lies againſt him would ſoon wear off, or be even converted into high eſteem, for thoſe exalted notions, and fine hints, that ſparkle and ſhine throughout his writings; which ſeem to contain not only the moſt valuable learning of Athens and Greece, but alſo a treaſure of the moſt remote traditions and early ſcience of the eaſt." Cudworth, and the learned author of *Ancient Metaphyſics*, are likewiſe ſtrenuous advocates for the Ariſtotelian doctrine of a plaſtic nature diffuſed through the material world; (ſee METAPHYSICS, N° 200, 201, 202.): and a notion very ſimilar has lately occurred

* *Siris*, N° 338.

Plastic.

occurred to a writer who does not appear to have borrowed it either from the *Lyceum* or the *Academy*.

This writer is Mr Young, of whose *active substance*, and its agency in moving bodies, some account has been given elsewhere, (see MOTION). As a mere unconscious agent, *immaterial*, and, as he expresses himself, *immental*, it bears a striking resemblance to the *plastic nature* or *vegetable life* of Cudworth: but the author holds it to be not only the principle of motion, but also the *basis* or *substratum* of matter itself; in the production of which, by certain motions, it may be said to be more strictly *plastic* than the *hylarchical* principle, or *vis genitrix*, of any other philosopher with whose writings we have any acquaintance. Though this opinion be singular, yet as its author is evidently a man who thinks for himself, unawed by the authority of celebrated names, and as one great part of the utility of such works as ours consists in their serving as indexes to science and literature, we shall lay before our readers a short abstract of the reasonings by which Mr Young endeavours to support his hypothesis, and we shall take the liberty of remarking upon those reasonings as we proceed.

The author, after a short introduction, enters upon his work ‡, in a chapter intitled, *Analysis of Matter in general*. In that chapter there is little novelty. He treats, as others have done, of primary and secondary qualities, and adheres too closely to the language of Locke, when he says, that "the nature of bodies signifies the aggregate of all those *ideas* with which they furnish us, and by which they are made known." To say the best of it, this sentence is inaccurately expressed. An aggregate of *ideas* may be occasioned by the impulse of bodies on the organs of sense, but the effect of impulse cannot be that which impels. We should not have made this remark, which may perhaps be deemed captious, were we not persuaded that the vague and inaccurate use of terms is the source of those mistakes into which, we cannot help thinking, that the very ingenious author has sometimes fallen. Having justly observed, that we know nothing directly of bodies but their qualities, he proceeds to investigate the nature of solidity.

‡ *An Essay on the powers and mechanism of nature.*

"Solidity (he says) is the quality of body which principally requires our notice. It is that which fills extension, and which resists other solids, occupying the place which it occupies; thus making extension and figure real, and different from mere space and vacuity. If the secondary qualities of bodies, or their powers variously to affect our senses, depend on their primary qualities, it is chiefly on this of solidity; which is therefore the most important of the primary qualities, and that in which the essence of body is by some conceived to consist. This idea of solidity has been judged to be incapable of any analysis; but it appears evident to me (continues our author), that the idea of solidity may be resolved into another idea, which is that of the power of resisting within the extension of body. Hence it becomes unnecessary, and even inadmissible, to suppose that solidity in the body is at all a pattern or archetype of our sensation."

That solidity in the body, and we know nothing of solidity any where else, is no pattern of any sensation of ours, is indeed most true, as we have shown at large in another place, (see METAPHYSICS, N° 44 and 171): but to reconcile this with what our author asserts immediately afterwards, that "solidity is no more in bodies than colours and flavours are, and that it is equally with them a *sensation* and an *idea*," would be a task to which our ingenuity is by no means equal. He affirms, indeed, that solidity, as it is said to be in bodies, is utterly incomprehensible; that we can perfectly comprehend it as a sensation in ourselves, but that in bodies nothing more is required than a power of active resistance to make upon our senses those impressions from which we infer the reality of primary and secondary qualities. This power of resistance, whether it ought to be called active or passive, we apprehend to be that which all other philosophers have meant by the word *solidity*; and though Locke, who uses the words *idea* and *notion* indiscriminately, often talks of the *idea* of solidity, we believe our author to be the first of human beings who has thought of treating *solidity* as a sensation in the mind.

Though it is wrong to innovate in language, when writing on subjects which require much attention, we must, however, acknowledge it to be unworthy of inquirers after truth to dispute about the proper or improper use of terms, so long as the meaning of him who employs them can be easily discovered. We shall, therefore, follow our author in his endeavours to ascertain what this power of resistance is which is commonly known by the name of solidity. All power he justly holds to be active; and having, by an argument (A) of which

"(A) We can only conceive of solidity as being a resistance of the *parts* of any body, to a power which endeavours to *separate* them, or to bring them *nearer* together. Now that which resists any power, and prevents its effect, is also a power. By resistance, I mean here an active resistance, such as an animal can employ against an animal. If a horse pulls against a load, he draws it along; but if he draws against another horse, he is put to a stand, and his endeavour is defeated. When any endeavour to change the situation of the parts of any solid is in like manner prevented from taking effect, and the parts retain their situation, the situation has plainly been preserved by an active resistance or power, equivalent to that which was fruitlessly exerted on them."

Such is our author's reasoning to prove that matter is essentially active, and that from this activity results our notion of its solidity: but does he not here confound solidity with hardness, and impenetrability with cohesion? He certainly does; for *water* is as *solid*, in the proper sense of the word, as *adamant*, and the particles of *air* as the particles of *iron*. The parts of water are, indeed, separated with ease, and those of adamant with difficulty; but it is not because the latter have more solidity than the former, but because the power of cohesion, whatever it may be, operates upon them with greater force. Solidity is an attribute of a whole; hardness and softness result from the cohesion of parts. We do not at all perceive the propriety of the simile of the horse pulling a load, and afterwards pulling against another horse. Is it because both horses are *active* that one of them cannot prevail against the other, and because the load is *inactive* that either of them may drag along a mass of iron of half a ton weight? If which we do not perceive the force, attempted to prove that it is by an inward *power*, and not by its *inertia*, that one body prevents another from occupying the fame place with itfelf, he naturally enough infers matter to be effentially active. "But the activity of matter is to be confidered in a certain limited fenfe, and its inertnefs is to be regarded in another limited fenfe; fo that thefe are compatible within their refpective limits. The activity of body may be confidered as belonging to the parts of a compound; its inertia as the inertia formed of thofe parts. The actions of the parts are everywhere oppofed to each other, and equal; and hence refults the inactivity of the whole."

Solidity alone of the primary qualities being pofitive, and peculiar to bodies, and our author having refolved this into action or power, it follows, by his analyfis, that the essence of body is reduced to power likewife. But, as he properly obferves, power is an idea of reflection, not acquired by the fenfes, but fuggefted by thought. Hence our knowledge of real exiftence in body muft be fuch as is fuggefted to us by our thoughts exercifed about our fenfations. "We are capable of acting and producing changes in appearances; and this faculty, which we experience to exift in ourfelves, we call power. We are confcious of the exertion of our own power; and therefore, when we fee action or change happen without any exertion of ours, we refer this to other powers without us, and neceffarily conclude the power to exift where the change begins or the action is exerted. This power, then, referred to bodies, muft exift in them, or it can exift no where."

In two chapters, which might eafily have been compreffed into one not fo long as the fhorteft of them, our author analyzes *atoms* or the primary particles of matter, and ftrenuoufly oppofes their impenetrability. He allows that there are atoms of matter not divifible by any known force; but as thefe, however fmall, muft ftill be conceived as having extenfion, each of them muft be compofed of parts held together by the fame power which binds together many atoms in the fame body. This power, indeed, he acknowledges to operate much more forcibly when it cements the parts of a primary atom than when it makes many atoms cohere in one mafs; but ftill it operates in the fame manner: and as the ideal analyfis may be carried on *ad infinitum*, the only pofitive idea which is fuggefted by atoms, or the parts of atoms, is the idea of a refifting power. That this power of refiftance, which conftitutes what is vulgarly called the folidity of bodies, may not be abfolutely impenetrable, he attempts to prove, by fhowing that refiftance does in fact take place in cafes where impenetrability, and even folidity, are not fuppofed by any man.

"Let us endeavour (fays he) to bring together two like poles of a magnet, and we fhall experience a refiftance to their approximation. Why, then, may not a piece of iron, which between our fingers refifts their coming together, refift by an efficacy perfectly fimilar, though more ftrongly exerted? If magnetifm were to act upon our bodies as upon iron, we fhould feel it; or were magnets endowed with fenfation, they would feel that which refifts their nearer approach. The refifting extenfion between the two magnets is permeable to all the rays of light, and reflecting none is therefore unfeen; but it is eafy to conceive that the fame power which refifts the approach of the iron might refift and reflect fome rays of light. We fhould then have a vifible object interpofed between the two magnets, as we have before fuppofed it might be a tangible one. It is likewife eafy to conceive that which is tangible and vifible fo applied to our organs of tafting, of fmelling, and of hearing, as to excite ideas of flavours, odours, and founds. Thus we fee that an action, in which no fuppofition of folidity or impenetrability is involved, may be conceived to affume all the qualities of matter, by only fuppofing a familiar effect extended in its operation."

This reafoning is exceedingly ingenious, though perhaps not original; but what is of more importance, it does not approach fo near to demonftration as the author feems to imagine. If magnets operate by means of a fluid iffuing from them (fee Magnetism), thofe who hold the folidity or impenetrability of matter will maintain, that each atom of the magnetic fluid is folid and impenetrable. That we do not fee nor feel thefe atoms, will be confidered as no argument that they do not exift; for we do not fee, nor in a clofe room feel, the atoms of the furrounding atmofphere; which yet Mr Young will acknowledge to have a real exiftence, and to be capable of operating upon our fenfes of hearing and fmelling. Let us, however, fuppofe, that by this reafoning he has eftablifhed the non-exiftence of every thing in the primary atoms of matter but active powers of refiftance, and let us fee how he conceives the actions of thefe powers to conftitute what gives us the notion of inert and folid body; for that we have fuch a notion cannot be denied.

To act he allows to be an attribute, and juftly obferves, that we cannot conceive an attribute to exift without a fubftance. "But (fays he) we have traced all phenomena to action as to a generic idea, comprehending under it all forms of matter and motion as fpecies of that genus. By this analyfis, that complex idea we have ufually denominated matter, and confidered as the fubftance or fubftratum to which motion appertained as an attribute, is found to change its character, and to be itfelf an attribute of a fubftance effentially active, of which one modification of motion produces matter and another generates motion." The action of this fubftance Mr Young determines to be motion, (fee Motion, N° 16.); and he proceeds to inquire by what kind of motion it produces matter, or inert and refifting atoms.

"Whatever portion of the active substance is given to form an atom, the following things are neceffary to be united in fuch portion of active fubftance: *1ft*, It muft in fome refpect continually move; for otherwife it would lofe its nature, and ceafe to be active. *2dly*, It muft alfo in fome other refpect be at reft, for otherwife it could not form an inactive atom. *3dly*, It muft preferve unity within itfelf." The author's proof

If fo, double or triple the mafs, and a very ftrange phenomenon will be the refult; for we fhall have an active whole compounded of two or three inactive parts, even though thofe parts fhould not be in contact!

proof of the firſt of theſe poſitions we have given elſewhere. The ſecond he holds to be ſelf-evident; and the third he thinks eſtabliſhed by the following reaſoning: "Solidity is the reſult of thoſe actions among the parts of any whole, whereby the unity of the whole is preſerved within itſelf. Several uncohering things may be united by an external bond: this does not conſtitute theſe one ſolid; it may be one bundle: but if ſeveral things cohere, and have a unity preſerved within themſelves, they become one ſolid. An atom is the leaſt and moſt ſimple ſolid."

Having thus proved the neceſſity of theſe three requiſites to the formation of an atom, he obſerves, that "the two firſt can only be united in a rotation of the portion of active ſubſtance about a centre or axis at reſt. By ſuch a motion, *all the parts* ſucceſſively occupy *different places* in the orbit of rotation, and therefore move; the centre round which they revolve being at reſt, the *whole portion* is alſo at reſt; and thus the portion is at once moving and quieſcent, as is required. The ſame kind of motion will alſo fulfil the terms of the third requiſite; for a ſubſtance having a revolving motion around its own centre, preſerves its unity by reaſon of all the parts preſerving the ſame relation to the centre: and further, a motion of the active ſubſtance about a centre or axis will be an activity in the ſame orbit, which will act upon and reſiſt whatever ſhall interfere to oppoſe its activity, or deſtroy the unity of the ſphere, by diverting the courſe of the revolving motions. The activity or motion of a portion of ACTIVE SUBSTANCE about a centre will, therefore, give ſolidity to ſuch portion; for it will give it unity and reſiſtance, and in a manner tie together all the parts, forming them into one maſs about their common centre: for they move or are active not *towards* the centre, in which caſe they would be loſt in non-extenſion; nor *from* the centre, where they would diſſipate in boundleſs ſpace; but *about* the centre, preſerving the ſame limits of extenſion: and being in this way active, they in this way reſiſt any other activity oppoſed to them, that is, they reſiſt any action which tends to penetrate or divide this ſphere of revolving activity. Therefore, ſince any portion of active ſubſtance does, by revolving about a centre, become an united, reſiſting, and quieſcent whole, the ſmalleſt portions of the ACTIVE SUBSTANCE which have ſuch motions will become *atoms*, or make the ſmalleſt portions of matter."

Having thus ſhown to his own ſatisfaction how atoms of matter are formed, he next explains what at firſt he confeſſes may have appeared a paradox, "how the ACTIVE SUBSTANCE, retaining its own nature and eſſential properties, continuing immaterial, unſolid, and active, puts on at the ſame time the form of matter, and becomes material, ſolid, and inert. A ſphere of revolving active ſubſtance, as it revolves continually about a centre, and as parts of the ſubſtance, are conſidered as ſucceſſively paſſing through every point in the orbit; conſidered thus in its parts, and in its motions, it is ACTIVE SUBSTANCE, immaterial, and unſolid; but the whole ſphere, conſidered unitically, collectively, and as quieſcent, is in this point of view a ſolid atom, material, and inert."

Such is the active ſubſtance of Mr Young, and ſuch his theory of the formation of matter. That he has not with ſervility copied from the ancients, every reader of his book, who is not an abſolute ſtranger to Greek and Roman literature, will readily acknowledge; and yet if his theory be well founded, he has diſcovered a middle ſubſtance between mind and matter, more properly *plaſtic* than Ariſtotle or Plato, Cudworth or Berkeley, ever conceived. But truth compels us to add, that to us his theory appears to labour under inſuperable objections. That there *may* be in the univerſe a ſubſtance eſſentially active, and at the ſame time not intelligent, is a propoſition which we are by no means inclined to controvert. Various phenomena, both in vegetable and animal life, lead us to ſuſpect that there is ſuch a ſubſtance; but it does not follow that we are inclined to adopt our author's doctrine reſpecting the formation of matter. He conceives his proof, indeed, to be "in its nature not at all imperfect, or to fall ſhort of demonſtration; and if any one refuſe it, he thinks it will be neceſſary for him to ſhow, either that the explanation offered is not ſufficient, or that ſome other explanation will ſerve equally well."

To ſhow that the explanation offered is not ſufficient, will not, we apprehend, be a very arduous taſk; but we have no inclination to attempt ourſelves another explanation, becauſe we believe that of the formation of matter no other account can be given than that which reſolves it into the *fiat* of the Creator. That it cannot be formed by the motion of an immaterial ſubſtance in the manner which our author has very clearly deſcribed, ſeems to be a truth ſo evident as not to admit of proof; for if motion be, as he defines it, a change of place, every thing that is moved muſt have the quality of extenſion. But all the parts of this active ſubſtance which are given to form an atom, move round a centre, and are expreſsly ſaid to occupy ſucceſſively different *places* in the orbit of rotation. Every one of theſe parts, therefore, is an extended being: and ſince, according to our author, ſolidity is nothing but an *active power of reſiſtance*, and the parts of this active ſubſtance, in their rotation round their centre, *act upon* and *reſiſt* whatever interferes to oppoſe their activity, it follows that each of theſe parts is likewiſe a *ſolid being*. But, in the opinion of Mr Young himſelf, and of all mankind, whatever is extended and ſolid is material. This theory, therefore, exhibits a proceſs in which atoms are formed of a ſubſtance, which, though it is ſaid to be *active*, *immaterial*, and unſolid, appears, when narrowly inſpected, to be nothing elſe than a collection of thoſe very atoms of which the author pretends to explain the formation. Mr Young, who examines and very freely cenſures ſome of the doctrines of Newton and others, is too much a man of ſcience to be offended at us for ſtating objections to a theory which is quite new, to a transformation which he himſelf acknowledges may to many "appear not only problematical and difficult to conceive, but wholly impoſſible, and implying contradictions abſolutely and for ever irreconcileable." Whether this be a juſt character of it our readers muſt determine; but if we did not believe the author to be a man of ingenuity, we ſhould not have introduced him or his work to their acquaintance.

PLASTIC Art, the art of repreſenting all ſorts of figures by the means of moulds. This term is derived from the Greek word πλαϛικη, which ſignifies the "art of forming, modelling, or caſting, in a mould." A mould in general is a body that is made hollow for that purpoſe. The artiſt makes uſe of it to form figures in bronze, Plastic.

bronze, lead, gold, silver, or any other metal or fusible substance. The mould is made of clay, stucco, or other composition, and is hollowed into the form of the figure that is to be produced; they then apply the jet, which is a sort of funnel, through which the metal is poured that is to form the figures, and that is called *running the metal into the mould.*

It is in this manner, but with much practice and attention, that the artist forms, 1. Equestrian and pedestrian statues of every kind; 2. Groups; 3. Pedestals; 4. Bass-reliefs; 5. Medallions; 6. Cannons, mortars, and other pieces of artillery; 7. Ornaments of architecture, as capitals, bases, &c.; 8. Various sorts of furniture, as lustres, branches, &c. in every kind of metal: and in the same manner figures are cast in stucco, plaster, or any other fusible matter. See *PLASTER of Paris.*

Wax being a substance that is very easily put in fusion, plastics make much use of it. There are impressions which are highly pleasing in coloured wax, of medallions, basso and alto relievos, and of detached figures; which, however, are somewhat brittle. But this matter has been carried too far: they have not only formed moulds to represent the likeness and the bust of a living person, by applying the plaster to the face itself, and afterwards casting melted wax into the mould; but they have also painted that waxen bust with the natural colours of the face, and have then applied glass eyes and natural hair; to which they have joined a stuffed body and limbs, with hands of wax; and have, lastly, dressed their figure in a real habit; and by these means have produced an object the most shocking and detestable that it is possible to conceive. It is not a statue, a bust, a natural resemblance that they form; but a dead body, a lifeless countenance, a mere carcase. The stiff air, the inflexible muscles, the haggard eyes of glass, all contribute to produce an object that is hideous and disgustful to every man of taste. Figures like these offend by affording too exact an imitation of nature. In no one of the polite arts ought imitation ever to approach so near the truth as to be taken for nature herself. Illusion must have its bounds; without which it becomes ridiculous.

There is another invention far more ingenious and pleasing, which is that wherein M. Lippart, antiquary and artist at Dresden, has so much excelled. He has found the means of resembling, by indefatigable labour, great expence, and infinite taste, that immense nnmber of stones, engraved and in camaieu, which are to be seen in the most celebrated cabinets. He has made choice of those that are the most beautiful; and, with a paste of his own invention, he takes from these stones an impression that is surprisingly accurate, and which afterwards become as marble: these impressions he calls *pasti.* He then gives them a proper colour, and incloses each with a gold rim; and, by ranging them in a judicious order, forms of them an admirable system. They are fixed on pasteboards, which form so many drawers, and are then inclosed in cases, which represent folio volumes, and have titles wrote on their backs; so that these fictitious books may conveniently occupy a place in a library. Nothing can be more ingenious than this invention; and, by means of it, persons of moderate fortune are enabled to make a complete collection of all antiquity has left that is excellent of this kind; and the copies are very little inferior to the originals.

Plastic, Plata.

There is also another method of taking the impressions of camaieus, medals, and coins, which is as follows: They wash or properly clean the piece whose impression is to be taken, and surround it with a border of wax. They then dissolve isinglass in water, and make a decoction of it, mixing with it some vermilion, to give it an agreeable red colour. They pour this paste, when hot, on the stone or medal, to the thickness of about the tenth part of an inch; they then leave it exposed to the sun, in a place free from dust. After a few days this paste becomes hard, and offers to the eye the most admirable and faithful representation of the medal that it is possible to conceive: they are then carefully placed in drawers; and thousands of these impressions, which comprehend many ages, may be included in a small compass.

The proficients in plastics have likewise invented the art of casting in a mould papier maché or dissolved paper, and forming it into figures in imitation of sculpture, of ornaments and decorations for ceilings, furniture, &c. and which they afterwards paint or gild. There are, however, some inconveniences attending this art; as, for example, the imperfections in the moulds, which render the contours of the figures inelegant, and give them a heavy air: these ornaments, moreover, are not so durable as those of bronze or wood, seeing that in a few years they are preyed on by the worm.

The figures that are given to porcelain, Delft ware, &c. belong also to plastics; for they are formed by moulds, as well as by the art of the sculptor and turner; and by all these arts united are made vases of every kind, figures, groups, and other designs, either for use of ornament.

From this general article the reader is referred to FOUNDERY, CAST, GLAZING, PORCELAIN, *PAPIER-Maché*, POTTERY, *DELFT Ware.*

PLATA, the name of a very great river of South America, running through the province of Paraguay; whence the whole country is sometimes called *Plata;* though this name is usually bestowed only upon a part of Paraguay. In the latter sense it comprehends all that country bounded on the east and south-east by the Atlantic ocean; on the south, by Terra Magellanica; on the west, by Tucuman; and on the north, by the provinces of Paraguay Proper and Parana. The great river La Plata, from which the country has its name, was first discovered, in 1515, by Juan Diaz de Solis; but denominated *La Plata* by Sebastian Gabato, from the great quantity of the precious metals he procured from the adjacent inhabitants, imagining it was the produce of the country, though in fact they brought it from Peru.

The country lies between 32° and 37° of south latitude. The climate is pleasant and healthy. Their winter is in May, June, and July, when the nights are indeed very cold, but the days moderately warm; the frost is neither violent nor lasting, and the snows are very inconsiderable.

The country consists mostly of plains of a vast extent, and exceeding rich soil, producing all sorts of European and American fruits, wheat, maize, cotton, sugar, honey, &c. and abounding with such excellent pastures, that the beasts brought hither from Spain are multiplied to such a degree, that they are all in common, no man claiming any property in them, but every man takes what he hath occaſion for. The number of black cattle, eſpecially, is ſo prodigious, that many thouſands of them are killed merely for their hides, every time the ſhips go for Spain, and their carcaſes left to be devoured by wild beaſts and birds of prey, which are alſo very numerous. Sometimes, when they cannot vend their hides, they will kill them for their tongues; and thoſe who care not to be at the trouble to fetch them from the plains, may buy them for a trifle. There is a curious account in Lord Anſon's voyage of the manner of hunting them on horſeback; and of catching and killing them, by throwing a nooſe on their horns at full gallop, the horſes being trained to the ſport. Horſes are no leſs numerous, and in common like the other cattle; ſo that a man may have as many as he pleaſes for the catching; and of thoſe that are already broke, one may buy ſome of the beſt, and of the true Spaniſh breed, for a piece-of-eight per head. Wild-fowl alſo is in great plenty here; partridges in particular are more numerous, and as large and tame as our hens, ſo that one may kill them with a ſtick. Their wheat makes the fineſt and whiteſt of bread; and, in a word, they ſeem to want for nothing here, eſpecially the natives, but ſalt and fuel. The former the Spaniards have brought to them from other parts; and the latter they ſupply themſelves with, by planting vaſt numbers of almond, peach, and other trees, which require no other trouble than putting the kernels into the ground, and by the next year, we are told, they begin to bear fruit. The return for European commodities is ſo great here, that it almoſt exceeds belief; an ordinary two-penny knife fetching a crown, and a gun of the value of 10 or 12 ſhillings 20 or 30 crowns, and ſo of the reſt.

The river Plata riſes in Peru, and receives a great many others in its courſe; the chief of which is the Paraguay. The water of it is ſaid to be very clear and ſweet, and to petrify wood; and contains ſuch plenty and variety of fiſh, that the people catch great quantities of them without any other inſtrument than their hands. It runs moſtly to the ſouth and ſouth-eaſt; and is navigable the greater part of its courſe by the largeſt veſſels, and full of delightful iſlands. All along its banks are ſeen the moſt beautiful birds of all kinds; but it ſometimes overflows the adjacent country to a great extent, and is infeſted by ſerpents of a prodigious bigneſs. From its junction with the Paraguay to its mouth it is above 200 leagues. We may form ſome judgement of its largeneſs by the width of its mouth, which is ſaid to be about 70 leagues. Before it falls into the Paraguay it is called *Panama*. See PANAMA.

PLATÆÆ, in *Ancient Geography*, a very ſtrong town of Bœotia, in its ſituation expoſed to the north wind (Theophraſtus); burnt to the ground by Xerxes (Herodotus, Juſtinus); mentioned much in the courſe of the Perſian war: Famous for the defeat of Mardonius, the Perſian general; and for the moſt ſignal victory of the Lacedemonians and other Greeks under Pauſanias the Lacedemonian, and Ariſtides an Athenian general (Nepos, Diodorus, Plutarch); in memory of which the Greeks erected a temple to Jupiter Eleutherius, and inſtituted games which they called *Eleutheria;* and there they ſhow the tombs of thoſe who fell in that battle (Strabo). It ſtood at the foot of Mount Cithæron, between that and Thebes to the north, on the road to Athens and Megara, and on the confines of Attica and Megaris. Now in ruins.

PLATALEA, the SPOONBILL, a genus of birds belonging to the order of grallæ. See ORNITHOLOGY *Index*.

PLATANUS, the PLANE-TREE; a genus of plants belonging to the monœcia claſs. See BOTANY *Index*.

PLATBAND, in *Gardening*, a border or bed of flowers, along a wall, or the ſide of a parterre, frequently edged with box, &c.

PLATBAND of a door or window, is uſed for the lintel, where that is made ſquare, or not much marked.

PLATE, a term which denotes a piece of wrought ſilver, ſuch as the ſhallow veſſel off which meat is eaten. It is likewiſe uſed by ſportſmen to expreſs the reward given to the beſt horſe at our races.

Sportſman's Dictionary.

The winning a plate is not the work of a few days to the owner of the horſe; but great care and preparation is to be made for it, if there is any great dependence on the ſucceſs. A month is the leaſt time that can be allowed to draw the horſe's body clear, and to refine his wind to that degree of perfection that is attainable by art.

It is firſt neceſſary to take an exact view of his body, whether he be low or high in fleſh; and it is alſo neceſſary to conſider whether he be dull and heavy, or briſk and lively when abroad. If he appear dull and heavy, and there is reaſon to ſuppoſe it is owing to too hard riding, or, as the jockeys expreſs it, to ſome greaſe that has been diſſolved in hunting, and has not been removed by ſcouring, then the proper remedy is half an ounce of diapente given in a pint of good ſack; this will at once remove the cauſe, and revive the creature's ſpirits. After this, for the firſt week of the month, he is to be fed with oats, bread, and ſplit beans; giving him ſometimes the one and ſometimes the other as he likes beſt; and always leaving ſome in the locker, that he may feed at leiſure when he is left alone. When the groom returns at the feeding-time, whatever is left of this muſt be removed, and freſh given; by this means the creature will ſoon become high-ſpirited, wanton, and full of play. Every day he muſt be rode out an airing, and every other day it will be proper to give him a little more exerciſe; but not ſo much as to make him ſweat too much. The beans and oats in this caſe are to be put into a bag, and beaten till the hulls are all off, and then winnowed clean; and the bread, inſtead of being chipped in the common way, is to have the cruſt clean cut off. If the horſe be in good fleſh and ſpirits when taken up for its month's preparation, the diapente muſt be omitted; and the chief buſineſs will be to give him good food, and ſo much exerciſe as will keep him in wind, without overſweating him or tiring his ſpirits. When he takes larger exerciſes afterwards, towards the end of the month, it will be proper to have ſome horſes in the place to run againſt him. This will put him upon his mettle, and the beating them will give him ſpirits. This, however, is to be cautiouſly obſerved, that he has not a bloody heat given him for ten days or a fortnight before the plate is to be run for; and that the laſt heat that is given him the day before the race, muſt be in his clothes: this will make him run with greatly more vigour, when ſtripped for the race, and feeling the cold wind on every part.

In the ſecond week, the horſe ſhould have the ſame food,

food, and more exercife. In the laft fortnight, he muft have dried oats, that have been hulled by beating. After this they are to be wetted in a quantity of whites of eggs beaten up, and then laid out in the fun to dry; and when as dry as before, the horfe is to have them. This fort of food is very light of digeftion, and very good for the creature's wind. The beans in this time fhould be given more fparingly, and the bread fhould be made of three parts wheat and one part beans. If he fhould become coftive under this courfe, he muft then have fome ale and whites of eggs beaten together; this will cool him, and keep his body moift.

In the laft week the mafh is to be omitted, and barley-water given him in its place, every day, till the day before the race: he fhould have his fill of hay; then he muft have it given him more fparingly, that he may have time to digeft it; and in the morning of the race day he muft have a toaft or two of white bread foaked in fack, and the fame juft before he is let out to the field. This is an excellent method, becaufe the two extremes of fullnefs and fafting are at this time to be equally avoided: the one hurting his wind, and the other occafioning faintnefs that may make him lofe. After he has had his food, the litter is to be fhook up, and the ftable kept quiet, that he may be difturbed by nothing till he is taken out to run.

PLATFORM, in the military art, an elevation of earth, on which cannon is placed to fire on the enemy; fuch are the mounts in the middle of curtins. On the ramparts there is always a platform, where the cannon are mounted. It is made by the heaping up of earth on the rampart, or by an arrangement of madriers, rifing infenfibly, for the cannon to roll on, either in a cafemate or on attack in the outworks. All practitioners are agreed, that no fhot can be depended on, unlefs the piece can be placed on a folid platform; for if the platform fhakes with the firft impulfe of the powder, the piece muft likewife fhake, which will alter its direction, and render the fhot uncertain.

Platform, in *Architecture*, is a row of beams which fupport the timber-work of a roof, and lie on the top of a wall where the entablature ought to be raifed.

This term is alfo ufed for a kind of terrace or broad fmooth open walk at the top of a building, from whence a fair profpect may be taken of the adjacent country. Hence an edifice is faid to be covered with a platform, when it is flat at top, and has no ridge. Moft of the oriental buildings are thus covered, as were all thofe of the ancients.

Platform, or *Orlop*, in a man of war, a place on the lower deck, abaft the main-maft, between it and the cockpit, and round about the main capftan, where provifion is made for the wounded men in time of action.

PLATINA is a metallic fubftance, the name of which has an allufion to its colour. It is a diminutive of *plata*, and fignifies "little filver." From its great fpecific gravity, and other refemblances which it has to gold, it has been called *or blanc*, or *white gold;* from its refractory nature, *diabolus metallorum;* from fome doubts entertained of its character as a metal, *juan blanco*, *white jack*, *white rogue*, or *white mock metal.* It has alfo received the appellation of the *eighth metal:* and, probably from fome diftrict which affords it, has gotten the name of *platina del Pinto*. For an account of its properties, and for its natural hiftory, fee Chemistry; Mineralogy; and *Ores, Reduction of.*

PLATING is the art of covering bafer metals with a thin plate of filver either for ufe or for ornament. It is faid to have been invented by a fpur-maker, not for fhow but for real utility. Till then the more elegant fpurs in common ufe were made of folid filver, and from the flexibility of that metal they were liable to be bent into inconvenient forms by the flighteft accident. To remedy this defect, a workman at Birmingham contrived to make the branches of a pair of fpurs hollow, and to fill that hollow with a flender rod of fteel or iron. Finding this a great improvement, and being defirous to add cheapnefs to utility, he continued to make the hollow larger, and of courfe the iron thicker and thicker, till at laft he difcovered the means of coating an iron fpur with filver in fuch a manner as to make it equally elegant with thofe which were made wholly of that metal. The invention was quickly applied to other purpofes; and to numberlefs utenfils which were formerly made of brafs or iron are now given the ftrength of thefe metals, and the elegance of filver, for a fmall additional expence.

The filver plate is generally made to adhere to the bafer metal by means of folder; which is of two kinds, the *foft* and the *hard*, or the *tin* and *filver* folders. The former of thefe confifts of tin alone, the latter generally of three parts of filver and one of brafs. When a buckle, for inftance, is to be plated by means of the foft folder, the ring, before it is bent, is firft tinned, and then the filver-plate is gently hammered upon it, the hammer employed being always covered with a piece of cloth. The filver now forms, as it were, a mould to the ring, and whatever of it is not intended to be ufed is cut off. This mould is faftened to the ring of the buckle by two or three cramps of fmall iron-wire; after which the buckle, with the plated fide undermoft, is laid upon a plate of iron fufficiently hot to melt the tin, but not the filver. The buckle is then covered with powdered refin or anointed with turpentine; and left there fhould be a deficiency of tin, a fmall portion of rolled tin is likewife melted on it. The buckle is now taken off with a tongs, and commonly laid on a bed of fand, where the plate and the ring, while the folder is yet in a ftate of fufion, are more clofely compreffed by a fmart ftroke with a block of wood. The buckle is afterwards bent and finifhed.

Sometimes the melted tin is poured into the filver mould, which has been previoufly rubbed over with fome flux. The buckle ring is then put among the melted tin, and the plating finifhed. This is called by the workmen *filling up*.

When the hard folder is employed, the procefs is in many refpects different. Before the plate is fitted to the iron or other metal, it is rubbed over with a folution of borax. Stripes of filver are placed along the joinings of the plate; and inftead of two or three cramps, as in the former cafe, the whole is wrapped round with fmall wire; the folder and joinings are again rubbed with the borax, and the whole put into a charcoal fire till the folder be in fufion. When taken out, the wire is inftantly removed, the plate is cleaned by the application of fome acid, and afterwards made fmooth by the ftrokes of a hammer.

Metal;

Plating, Plato.

Metal plating is when a bar of ſilver and copper are taken of at leaſt one equal ſide. The equal ſides are made ſmooth, and the two bars faſtened together by wire wrapped round them. Theſe bars are then ſweated in a charcoal fire, and after ſweating, they adhere as cloſely together as if they were ſoldered. After this they are flattened into a plate between two rollers, when the copper appears on one ſide and the ſilver on the other. This ſort of plate is named *plated metal*.

French plating is when ſilver-leaf is burniſhed on a piece of metal in a certain degree of heat.

When ſilver is diſſolved in aquafortis, and precipitated upon another metal, the proceſs is called *ſilvering*. See SOLDERING.

PLATO, an illuſtrious philoſopher of antiquity, was by deſcent an Athenian, though the place of his birth was the iſland of Egina. His lineage through his father is traced back to Codrus the laſt king of Athens, and through his mother to Solon the celebrated legiſlator. The time of his birth is commonly placed in the beginning of the 88th Olympiad; but Dr Enfield thinks it may be more accurately fixed in the third year of the 87th Olympiad, or 430 years before the Chriſtian era. He gave early indications of an extenſive and original genius, and had an education ſuitable to his high rank, being inſtructed in the rudiments of letters by the grammarian Dionyſius, and trained in athletic exerciſes by Ariſto of Argos. He applied with great diligence to the ſtudy of the arts of painting and poetry; and made ſuch proficiency in the latter, as to produce an epic poem, which, upon comparing it with the poems of Homer, he committed to the flames. At the age of 20 he compoſed a dramatic piece; but after he had given it to the performers, happening to attend upon a diſcourſe of Socrates, he was ſo captivated by his eloquence, that he reclaimed his tragedy without ſuffering it to be acted, renounced the muſes, burnt all his poems, and applied himſelf wholly to the ſtudy of wiſdom.

It is thought that Plato's firſt maſters in philoſophy were Cratylus and Hermogenes, who taught the ſyſtems of Heraclitus and Parmenides; but when he was 20 years old, he attached himſelf wholly to Socrates, with whom he remained eight years in the relation of a ſcholar. During this period, he frequently diſpleaſed his companions, and ſometimes even his maſter, by grafting upon the Socratic ſyſtem opinions which were taken from ſome other ſtock. It was the practice of the ſcholars of Socrates to commit to writing the ſubſtance of their maſter's diſcourſes. Plato wrote them in the form of dialogues; but with ſo great additions of his own, that Socrates, hearing him recite his Lyſis, cried out, "O Hercules! how many things does this young man feign of me!"

Plato, however, retained the warmeſt attachment to his maſter. When that great and good man was ſummoned before the ſenate, his illuſtrious ſcholar undertook to plead his cauſe, and begun a ſpeech in his defence; but the partiality and violence of the judges would not permit him to proceed. After the condemnation, he preſented his maſter with money ſufficient to redeem his life; which, however, Socrates refuſed to accept. During his impriſonment, Plato attended him, and was preſent at a converſation which he held with his friends concerning the immortality of the ſoul; the ſubſtance of which he afterwards committed to writing in the beautiful dialogue intitled *Phædo*, not, however, without interweaving his own opinions and language.

Plato.

The philoſophers who were at Athens were ſo alarmed at the death of Socrates, that moſt of them fled from the city to avoid the injuſtice and cruelty of the government. Plato, whoſe grief upon this occaſion is ſaid by Plutarch to have been exceſſive, retired to Megara; where he was kindly entertained by Euclid, who had been one of Socrates's firſt ſcholars, till the ſtorm was over. Afterwards he determined to travel in purſuit of knowledge; and from Megara he went to Italy, where he conferred with Eurytus, Philolaus, and Archytas. Theſe were the moſt celebrated of the followers of Pythagoras, whoſe doctrine was then become famous in Greece; and from theſe the Pythagoreans have affirmed that he had all his natural philoſophy. He dived into the moſt profound and myſterious ſecrets of the Pythagoric doctrines; and perceiving other knowledge to be connected with them, he went to Cyrene, where he learned geometry of Theodorus the mathematician. From thence he paſſed into Egypt, to acquaint himſelf with the theology of their prieſts, to ſtudy more nicely the proportions of geometry, and to inſtruct himſelf in aſtronomical obſervations; and having taken a full ſurvey of all the country, he ſettled for ſome time in the province of Sais, learning of the wiſe men there, what they held concerning the univerſe, whether it had a beginning, whether it moved wholly or in part, &c.; and Pauſanias affirms, that he learned from theſe the immortality, and alſo the tranſmigration, of ſouls. Some of the fathers will have it, that he had communication with the books of Moſes, and that he ſtudied under a learned Jew of Heliopolis; but there is nothing that can be called evidence for theſe aſſertions. St Auſtin once believed that Plato had ſome conference with Jeremiah; but afterwards diſcovered, that that prophet muſt have been dead at leaſt 60 years before Plato's voyage to Egypt.

Plato's curioſity was not yet ſatisfied. He travelled into Perſia to conſult the magi about the religion of that country: and he deſigned to have penetrated even to the Indies, and to have learned of the Brachmans their manners and cuſtoms; but the wars in Aſia prevented him.

"He then returned into Italy, to the Pythagorean ſchool at Tarentum, where he endeavoured to improve his own ſyſtem, by incorporating with it the doctrine of Pythagoras, as it was then taught by Archytas, Timæus, and others. And afterwards, when he viſited Sicily, he retained ſuch an attachment to the Italic ſchool, that, through the bounty of Dionyſius, he purchaſed at a vaſt price ſeveral books which contained the doctrine of Pythagoras, from Philolaus, one of his followers.

"Returning home richly ſtored with knowledge of various kinds, Plato ſettled in Athens, and executed the deſign, which he had doubtleſs long had in contemplation, of forming a new ſchool for the inſtruction of youth in the principles of philoſophy. The place which he made choice of for this purpoſe was a public grove, called the *Academy*, from Hecademus, who left it to the citizens for the purpoſe of gymnaſtic exerciſes. Adorned with ſtatues, temples, and ſepulchres, planted with lofty plane-trees, and interſected by a gentle ſtream, it afforded a delightful retreat for philoſophy and the muſes. Of this retreat Horace ſpeaks:

Atque

Plato.

Atque inter sylvas Academi quærere verum.

"'Midst Academic groves to search for truth."

Within this inclosure he possessed, as a part of his humble patrimony, purchased at the price of three thousand drachmas, a small garden, in which he opened a school for the reception of those who might be inclined to attend his instructions. How much Plato valued mathematical studies, and how necessary a preparation he thought them for higher speculations, appears from the inscription which he placed over the door of his school: Ὀυδεὶς αγεω ἑτρητος εισιτω. "Let no one who is unacquainted with geometry enter here."

"This new school soon became famous, and its master was ranked among the most eminent philosophers. His travels into distant countries, where learning and wisdom flourished, gave him celebrity among his brethren of the Socratic sect. None of these had ventured to institute a school in Athens except Aristippus; and he had confined his instructions almost entirely to ethical subjects, and had brought himself into some discredit by the freedom of his manners. Plato alone remained to inherit the patrimony of public esteem which Socrates had left his disciples; and he possessed talents and learning adequate to his design of extending the study of philosophy beyond the limits within which it had been inclosed by his master. The consequence was, not only that young men crowded to his school from every quarter, but that people of the first distinction in every department frequented the academy. Even females, disguised in men's clothes, often attended his lectures. Among the illustrious names which appear in the catalogue of his followers are Dion the Syracusan prince, and the orators Hyperides, Lycurgus, Demosthenes, and Isocrates.

"Greatness was never yet exempted from envy. The distinguished reputation of Plato brought upon him the hatred of his former companions in the school of Socrates, and they loaded him with detraction and obloquy. It can only be ascribed to mutual jealousy, that Xenophon and he, though they relate the discourses of their common master, studiously avoid mentioning one another. Diogenes the Cynic ridiculed Plato's doctrine of ideas and other abstract speculations. In the midst of these private censures, however, the public fame of Plato daily increased; and several states, among which were the Arcadians and Thebans, sent ambassadors with earnest requests that he would come over, not only to instruct the young men in philosophy, but also to prescribe them laws of government. The Cyrenians, Syracusans, Cretans, and Eleans, sent also to him: he did not go to any of them, but gave laws and rules of governing to all. He lived single, yet soberly and chastely. He was a man of great virtues, and exceedingly affable; of which we need no greater proof, than his civil manner of conversing with the philosophers of his own times, when pride and envy were at their height. His behaviour to Diogenes is always mentioned in his history. The Cynic was vastly offended, it seems, at the politeness and fine taste of Plato, and used to catch all opportunities of snarling at him. He dined one day at his table with other company, and, trampling upon the tapestry with his dirty feet, uttered this brutish sarcasm, "I trample upon the pride of Plato;" to which Plato wisely reparteed, "With greater pride."

The fame of Plato drew disciples to him from all parts; among whom were Speusippus an Athenian, his sister's son, whom he appointed his successor in the academy, and the great Aristotle.

The admiration of this illustrious man was not confined to the breasts of a few philosophers. He was in high esteem with several princes, particularly Archelaus king of Macedon, and Dionysius tyrant of Sicily. At three different periods he visited the court of this latter prince, and made several bold but unsuccessful attempts to subdue his haughty and tyrannical spirit. A brief relation of the particulars of these visits to Sicily may serve to cast some light upon the character of our philosopher; and we shall give it in the words of Dr Enfield, from whose elegant history of philosophy we have extracted by much the most valuable parts of this article.

"The professed object of Plato's first visit to Sicily, which happened in the 40th year of his age, during the reign of the elder Dionysius the son of Hermocrates, was, to take a survey of the island, and particularly to observe the wonders of Mount Ætna. Whilst he was resident at Syracuse, he was employed in the instruction of Dion, the king's brother-in-law, who possessed excellent abilities, though hitherto restrained by the terrors of a tyrannical government, and relaxed by the luxuries of a licentious court. Disgusted by the debauched manners of the Syracusans, he endeavoured to rescue his pupil from the general depravity. Nor did Dion disappoint his preceptor's expectations. No sooner had he received a taste of that philosophy which leads to virtue, than he was fired with an ardent love of wisdom. Entertaining an hope that philosophy might produce the same effect upon Dionysius, he took great pains to procure an interview between Plato and the tyrant. In the course of the conference, whilst Plato was discoursing on the security and happiness of virtue, and the miseries attending injustice and oppression, Dionysius, perceiving that the philosopher's discourse was levelled against the vices and cruelties of his reign, dismissed him with high displeasure from his presence, and conceived a design against his life. It was not without great difficulty that Plato, by the assistance of Dion, made his escape. A vessel which had brought over Pollis, a delegate from Sparta, was fortunately at that time returning to Greece. Dion engaged Pollis to take the charge of the philosopher, and land him safely in his native country; but Dionysius discovered the design, and obtained a promise from Pollis, that he would either put him to death or sell him as a slave upon the passage. Pollis accordingly sold him in the island of Ægina; the inhabitants of which were then at war with the Athenians. Plato could not long remain unnoticed: Anicerris, a Cyrenaic philosopher, who happened to be at that time in the island, discovered the stranger, and thought himself happy in an opportunity of showing his respect for so illustrious a philosopher: he purchased his freedom for 30 minæ, or 84l. 10s. sterling money, and sent him home to Athens. Repayment being afterwards offered to Anicerris by Plato's relations, he refused the money, saying, with that generous spirit which true philosophy always inspires, that he saw no reason why the relations of Plato should engross to themselves the honour of serving him."

After a short interval, Dionysius repented of his ill-placed

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placed resentment, and wrote to Plato, earnestly requesting him to repair his credit by returning to Syracuse; to which Plato gave this high-spirited answer, that philosophy would not allow him leisure to think of Dionysius. He was, however, prevailed upon by his friend Dion to accept of the tyrant's invitation to return to Syracuse, and take upon him the education of Dionysius the younger, who was heir apparent to the monarchy. He was received by Dionysius the reigning sovereign with every possible appearance of respect; but after seeing his friend banished, and being himself kept as a prisoner at large in the palace, he was by the tyrant sent back into his own country, with a promise that both he and Dion should be recalled at the end of the war in which the Sicilians were then engaged. This promise was not fulfilled. The tyrant wished for the return of Plato; but could not resolve to recal Dion. At last, however, having probably promised that the philosopher should meet his friend at the court of Syracuse, he prevailed upon Plato to visit that capital a third time. When he arrived, the king met him in a magnificent chariot, and conducted him to his palace. The Sicilians too rejoiced in his return; for they hoped that the wisdom of Plato would at length triumph over the tyrannical spirit of the prince. Dionysius seemed wholly divested of his former resentments, listened with apparent pleasure to the philosopher's doctrine, and, among other expressions of regard, presented him with eighty talents of gold. In the midst of a numerous train of philosophers, Plato now possessed the chief influence and authority in the court of Syracuse. Whilst Aristippus was enjoying himself in splendid luxury; whilst Diogenes was freely indulging his acrimonious humour; and whilst Æschines was gratifying his thirst after riches;—Plato supported the credit of philosophy with an air of dignity, which his friends regarded as an indication of superior wisdom, but which his enemies imputed to pride. After all, it was not in the power of Plato to prevail upon Dionysius to adopt his system of policy, or to recal Dion from his exile. Mutual distrust, after a short interval, arose between the tyrant and the philosopher; each suspected the other of evil designs, and each endeavoured to conceal his suspicion under the disguise of respect. Dionysius attempted to impose upon Plato by condescending attentions, and Plato to deceive Dionysius by an appearance of confidence. At length, the philosopher became so much dissatisfied with his situation, that he earnestly requested permission to return to Greece, which was at last granted him, and he was sent home loaded with rich presents. On his way to Athens, passing through Elis during the celebration of the Olympic games, he was present at this general assembly of the Greeks, and engaged universal attention.

From this narrative it appears, that if Plato visited the courts of princes, it was chiefly from the hope of seeing his ideal plan of a republic realized; and that his talents and attainments rather qualified him to shine in the academy than in the council or the senate.

Plato, now restored to his country and his school, devoted himself to science, and spent the last years of a long life in the instruction of youth. Having enjoyed the advantage of an athletic constitution, and lived all his days temperately, he arrived at the 81st, or according to some writers the 79th, year of his age, and died, through the mere decay of nature, in the first year of the hundred and eighth Olympiad. He passed his whole life in a state of celibacy, and therefore left no natural heirs, but transferred his effects by will to his friend Adiamantus. The grove and garden, which had been the scene of his philosophical labours, at last afforded him a sepulchre. Statues and altars were erected to his memory; the day of his birth long continued to be celebrated as a festival by his followers; and his portrait is to this day preserved in gems: but the most lasting monuments of his genius are his writings, which have been transmitted, without material injury, to the present times.

The character of this philosopher has always been high. Besides the advantages of a noble birth, he had a large and comprehensive understanding, a vast fund of wit and good taste, great evenness and sweetness of temper, all cultivated and refined by education and travel; so that it is no wonder if he was honoured by his countrymen, esteemed by strangers, and adored by his scholars. The ancients thought more highly of Plato than of all their philosophers: they always called him the *Divine Plato;* and they seemed resolved that his descent should be more than human. "There are (says Apuleius) who assert Plato to have sprung from a more sublime conception; and that his mother Perictione, who was a very beautiful woman, was impregnated by Apollo in the shape of a spectre." Plutarch, Suidas, and others, affirm this to have been the common report at Athens. When he was an infant, his father Aristo went to Hymettus, with his wife and child, to sacrifice to the muses; and while they were busied in the divine rites, a swarm of bees came and distilled their honey upon his lips. This, says Tully, was considered as a presage of his future eloquence. Apuleius relates, that Socrates, the night before Plato was recommended to him, dreamed that a young swan fled from Cupid's altar in the academy, and settled in his lap; thence soared to heaven, and delighted the gods with its music: and when Aristo the next day presented Plato to him, "Friends (says Socrates), this is the swan of Cupid's academy." The Greeks loved fables: they show however in the present case, what exceeding respect was paid to the memory of Plato. Tully perfectly adored him; tells us, how he was justly called by Panætius the *divine*, the *most wise*, the *most sacred*, the *Homer of philosophers;* entitled him to Atticus, *Deus ille noster*; thinks, that if Jupiter had spoken Greek, he would have spoken in Plato's language, and made him so implicitly his guide in wisdom and philosophy, as to declare, that he had rather err with Plato than be right with any one else. But, panegyric aside, Plato was certainly a very wonderful man, of a large and comprehensive mind, an imagination infinitely fertile, and of a most flowing and copious eloquence. Nevertheless, the strength and heat of fancy prevailing in his composition over judgement, he was too apt to soar beyond the limits of earthly things, to range in the imaginary regions of general and abstracted ideas; and on which account, though there is always a greatness and sublimity in his manner, he did not philosophize so much according to truth and nature as Aristotle, though Cicero did not scruple to give him the preference.

The writings of Plato are all in the way of dialogue; where he seems to deliver nothing from himself, but every thing

Plato ‖ Platonism.

thing as the sentiments and opinions of others, of Socrates chiefly, of Timæus, &c. He does not mention himself anywhere, except once in his Phædo, and another time in his Apology for Socrates. His style, as Aristotle observed, is betwixt prose and verse: on which account, some have not scrupled to rank him with the poets. There is a better reason for so doing than the elevation and grandeur of his style: his matter is oftentimes the offspring of imagination, instead of doctrines or truths deduced from nature. The first edition of Plato's works in Greek was put out by Aldus at Venice in 1513; but a Latin version of him by Marsilius Ficinus had been printed there in 1491. They were reprinted together at Lyons in 1588, and at Francfort in 1602. The famous printer Henry Stephens, in 1578, gave a most beautiful and correct edition of Plato's works at Paris, with a new Latin version by Serranus, in three volumes folio; and this deservedly passes for the best edition of Plato: yet Serranus's edition is very exceptionable, and in many respects, if not in all, inferior to that of Ficinus.

PLATONIC, something that relates to Plato, his school-philosophy, opinions, or the like. Thus, platonic love denotes a pure spiritual affection, for which Plato was a great advocate, subsisting between the different sexes, abstracted from all carnal appetites, and regarding no other object but the mind and its beauties; or it is even a sincere disinterested friendship subsisting between persons of the same sex, abstracted from any selfish views, and regarding no other object than the person, if any such love or friendship has aught of a foundation in nature.

PLATONIC Year, or the *Great Year*, is a period of time determined by the revolution of the equinoxes, or the space wherein the stars and constellations return to their former places in respect of the equinoxes. The platonic year, according to Tycho Brahe, is 25816, according to Ricciolus 25910, and according to Cassini 24800 years.

This period once accomplished, it was an opinion among the ancients that the world was to begin anew, and the same series of things to turn over again.

PLATONISM, the philosophy of Plato, which was divided into three branches, *theology*, *physics*, and *mathematics*. Under *theology* were comprehended metaphysics and ethics, or that which in modern language is called *moral* philosophy. Plato wrote likewise on *dialectics*, but with such inferiority to his pupil Aristotle, that his works in that department of science are seldom mentioned.

The ancient philosophers always began their theological systems with some disquisition on the nature of the gods, and the formation of the world; and it was a fundamental doctrine with them, that *from nothing nothing can proceed*. We are not to suppose that this general axiom implied nothing more than that for every effect there must be a cause; for this is a proposition which no man will controvert who understands the terms in which it is expressed: but the ancients believed that a proper creation is impossible even to omnipotence, and that to the production of any thing a *material* is not less *necessary* than an *efficient* cause, (see METAPHYSICS, N° 264—304.). That with respect to this important question, Plato agreed with his predecessors and contemporaries, appears evident to us from the whole tenor of his *Timæus*. We agree with Dr Enfield * in thinking, that in this dialogue, which comprehends his whole doctrine on the subject of the formation of the universe, matter is so manifestly spoken of as eternally co-existing with God, that this part of his doctrine could not have been mistaken by so many learned and able writers, had they not been seduced by the desire of establishing a coincidence of doctrine between the writings of Plato and Moses. It is certain that neither Cicero †, nor Apuleius ‡, nor Alcinous §, nor even the later commentator Chalcidius, understood their master in any other sense than as admitting two primary and incorruptible principles, God and matter; to which we shall afterwards see reason to add a third, namely ideas. The passages quoted by those who maintain the contrary opinion are by no means sufficient for their purpose. Plato, it is true, in his Timæus, calls God the *parent of the universe*, and in his Sophista speaks of him as "forming animate and inanimate beings, which did not before exist:" but these expressions do not necessarily imply that this offspring of Deity was produced from nothing, or that no prior matter existed from which these new beings were formed. Through the whole dialogue of the Timæus, Plato supposes two eternal and independent causes of all things; one, that by which all things are made, which is God; the other, that from which all things are made, which is matter. He distinguishes between God, matter, and the universe, and supposes the architect of the world to have formed it out of a mass of pre-existent matter. Matter, according to Plato, is an eternal and infinite principle. His doctrine on this head is thus explained by Cicero ‖. "Matter, from which all things are produced and formed, is a substance without form or quality, but capable of receiving all forms, and undergoing every kind of change; in which, however, it never suffers annihilation, but merely a solution of its parts, which are in their nature infinitely divisible, and move in portions of space which are also infinitely divisible. When that principle which we call quality is moved, and acts upon matter, it undergoes an entire change, and those forms are produced, from which arises the diversified and coherent system of the universe." This doctrine Plato unfolds at large in his Timæus, and particularly insists upon the notion, that matter has originally no form, but is capable of receiving any. He calls it the mother and receptacle of forms, by the union of which with matter the universe becomes perceptible to the senses; and maintains, that the visible world owes its forms to the energy of the divine intellectual nature.

Our author is supported in drawing this inference by the testimony of Diogenes Laertius, who surely understood the language and dogmas of Plato better than the most accomplished modern scholar can pretend to do; yet a learned writer * has lately expressed great surprise that any one should consider matter as having been, in Plato's opinion, uncreated; and he boldly affirms, that Laertius, instead of asserting that spirit and matter were the principles of all things, ought to have said that God alone, in Plato's estimation, was their original.—To prove this, he gives from the Timæus a quotation, in which the founder of the academy declares that God *framed* heaven and earth, and the inferior deities; and that as he *fashioned*, so he pervades all nature. He observes, that Cicero denominates the god of

Platonism.

* *Hist of Philosophy.*

† *Ac. Qu.* lib. i. c. 6.
‡ Lib. i.
§ Cap. 12.

‖ *Ac. Qu.* lib. i. c. 8.

* *Dr Ogilvie.*

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Plato the *maker*, and the god of Aristotle only the *governor*, of the world. And, to satisfy those who may demand a particular proof of Plato's having taught a real creation, he affirms that his writings abound with declarations on the subject, of which the meaning cannot be misapprehended. "With this purpose (says he) Plato denominates at one time the principles or substance of all things, Γενοματα θεου Δημιουργον, the productions of the efficient Deity, and at others enters more particularly into the question. Thus, he observes, that many persons are ignorant of the nature and power of mind or intellect, 'as having existed at the beginning, antecedent to all bodies.' Of this mind, he observes, that it is without exception Παντων πρεσβυτατι, *of all things the most ancient;* and he subjoins, in order to remove all doubt of his purpose, that it is also Αρχη κινησεως, *the cause or principle of motion.*"

Theology of Plato.

With all possible respect for Dr Ogilvie, of whose piety and erudition we are thoroughly convinced, we must take the liberty to say, that to us the declarations of Plato on this subject appear much less precise and explicit than they appear to him; and that the inference which he would draw from the *words* of Cicero seems not to flow necessarily from the *sense* of those words. That Plato believed God to have *framed* the heaven and the earth, and to have *fashioned* all nature, is a position which, as far as we know, has never been controverted; but between *framing* or *fashioning* the chaos or ὑλη πρωτη, and calling the universe into existence from non-entity, there is an infinite and an obvious difference. The distinction made by Cicero between the God of Plato and the God of Aristotle is a just distinction, but it will not bear the superstructure which the learned doctor builds upon it. Aristotle maintained the eternity of the world in its present form. Plato certainly taught that the first matter was in time reduced from a chaotic state into *form* by the power of the Demiurgus; but we have seen nothing in his writings which explicitly declares his belief that the *first matter* was itself *created.*

The learned Cudworth, who wished, like Dr Ogilvie, to find a coincidence of doctrine between the theology of Plato and that of the Gospel, strained all his faculties to prove that his favourite philosopher taught a proper creation: but he laboured in vain. He gives a number of quotations in support of his position; of which we shall here insert only those two upon which Dr Ogilvie seems to lay the greatest stress. Plato, says the author of the Intellectual System, calls the one God (A) ὁς γην ουρανον και θεους, και ταυτα τα εν ουρανω και τα εν ᾁδου, και ὑπο γης ἁπαντα εργαζεται—*He that makes earth, and heaven, and the gods, and doth all things both in heaven, and hell, and under the earth.* And, again, "he by whose efficiency the things of the world (ὑστερον εγενετο, προτερον ουκ οντα) *were afterwards made when they were not before* *." Both Cudworth and Ogilvie think this last sentence an explicit declaration of Plato's belief in the creative power of God: but that they are mistaken has been evinced by Mosheim with a force of argument which will admit of no reply. In that part of *the Sophist* from which the quotation is taken, Plato considers the δυναμιν ποιητικην, of which he is treating, as belonging both to God and to man; and he defines it in general to be "a certain power which is the cause that things may afterwards be which were not before." Cudworth wishes to confine this definition to the divine power; and adds from himself to the text which he quotes the following words, which are not in Plato, or FROM AN ANTECEDENT NON-EXISTENCE BROUGHT FORTH INTO BEING! That the incomparable author intended to deceive his reader, we are far from imagining: his zeal for Platonism had deceived himself. Plato's definition comprehends the δυναμιν ποιητικης † as well of man as of God; and therefore cannot infer a creative power anywhere, unless the father of the academy was so very absurd as to suppose human artists the creators of those machines which they have invented and made! Mosheim thinks that Cudworth was misled by too implicit a confidence in *Ficinus;* and it is not impossible that Dr Ogilvie may have been swayed by the authority, great indeed, of the author of the Intellectual System.

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* *Sophista,* p. 168.

† *Mosch. ed. Cud. Syst. Intel.* cap. 4. § 23. n. 11.

That intellect existed antecedent to all bodies is indeed a Platonic dogma, from which Dr Ogilvie, after Cudworth, wishes to infer that the doctrine of the creation was taught in the academy; but Dr Ogilvie knows, and no man knew better than Cudworth, that Plato, with every other Greek philosopher, distinguished between *body* and *matter;* and that though he held the priority of intellect to the former, it by no means follows that he believed it to have existed antecedent to the latter. That he believed *mind,* or rather *soul* (for he distinguishes between the two), to be the cause or principle of motion, cannot be denied; but we are not therefore authorised to conclude, that he likewise believed it to be the cause of the existence of matter. That he believed mind to be the most ancient of *all things,* taking the word *things* in the most absolute sense, cannot be true, since by Dr Ogilvie's own acknowledgement he held the existence and eternity of *ideas,* not to add that he believed το ἑν or τ᾽αγαθον—the first hypostasis in his trinity, to be superior to mind and prior to it, though not in time, yet in the order of nature. When therefore he calls mind the most ancient of *all things,* he must be supposed to mean only, that it is more ancient than *all bodies* and inferior souls. It is no reflection on the character of Plato that he could not, by the efforts of his own reason, acquire any notion of a proper creation; since we, who have the advantage of his writings, and of writings

(A) Mosheim affirms that this quotation is nowhere to be found in the writings of Plato. He therefore at first suspected that the learned author, in looking hastily over Plato's 10th book *De Legibus,* had transferred to God what is there said of the *anima mundi,* leading by its own motions every thing in the heaven, the earth, and the sea, and that he had added something of his own. He dropped that opinion, however, when he found Plato, in the 10th book of his Republic, declaring it to be as "easy for God to produce the sun, moon, stars, and earth, &c. from himself, as it is for us to produce the image of ourselves, and whatever else we please, only by interposing a looking-glass." In all this power, however, there is nothing similar to that of creation.

writings infinitely more valuable, to instruct us, find it extremely difficult, if not impossible, to conceive how any thing can begin to be. We believe the fact on the authority of revelation; but should certainly have never agitated such a question, had it not been stated to us by writers inspired with celestial wisdom.

In the Platonic cosmogony we cannot therefore doubt but that the eternity of the ὑλη πρωτη was taken for granted. Whether it was an eternal and necessary emanation from an eternal mind, is not perhaps quite so evident, though our own opinion is, that it was believed to be self-existent. But be this as it may, which is not worth disputing, one thing is certain, that Plato did not believe it to have a single form or quality which it did not receive either from the *Demiurgus* or the *Psyche*—the second or third person of this trinity. Except Aristotle, all the Greek philosophers, who were not materialists, held nearly the same opinions respecting the origin of the world; so that in examining their systems we shall be greatly misled if we understand the terms *incorporeal* and *immaterial* as at all synonymous. It was also a doctrine of Plato, that there is in matter a necessary but blind and refractory force; and that hence arises a propensity in matter to disorder and deformity, which is the cause of all the imperfection which appears in the works of God, and the origin of evil. On this subject Plato writes with wonderful obscurity: but, as far as we are able to trace his conceptions, he appears to have thought, that matter, from its nature, resists the will of the Supreme Artificer, so that he cannot perfectly execute his designs; and that this is the cause of the mixture of good and evil which is found in the material world.

Plato, however, was no materialist. He taught, that there is an intelligent cause, which is the origin of all spiritual being, and the former of the material world. The nature of this great being he pronounced it difficult to discover, and when discovered, impossible to divulge. The existence of God he inferred from the marks of intelligence, which appear in the form and arrangement of bodies in the visible world: and from the unity of the material system he concluded, that the mind by which it was formed must be one. God, according to Plato, is the supreme intelligence, incorporeal, without beginning, end, or change, and capable of being perceived only by the mind. He certainly distinguished the Deity not only from body, and whatever has corporeal qualities, but from matter itself, from which all things are made. He also ascribed to him all those qualities which modern philosophers ascribe to immaterial substance: and conceived him to be in his nature simple, uncircumscribed in space, the author of all regulated motion, and, in fine, possessed of intelligence in the highest perfection.

His notions of God are indeed exceedingly refined, and such as it is difficult to suppose that he could ever have acquired but from some obscure remains of primeval tradition, gleaned perhaps from the priests of Egypt or from the philosophers of the East. In the Divine Nature he certainly believed that there are two, and probably that there are three, *hypostases*, whom he called το ον and το ἑν, νους and ψυχη. The first he considered as self-existent, and elevated far above all mind and all knowledge; calling him, by way of eminence, *the being*, or *the one*. The only attribute which he acknowledged in this person was goodness; and therefore he frequently styles him το αγαθον—*the good*, or *essential goodness*. The second he considered as mind, the *wisdom* or *reason* of the first, and the *maker of the world*; and therefore he styles him νους λογος and δημιουργος. The third he always speaks of as the *soul of the world*; and hence calls him ψυχη, or ψυχη του κοσμου. He taught that the *second* is a necessary emanation from the *first*, and the *third* from the *second*, or perhaps from the *first* and *second*.

Some have indeed pretended, that the *Trinity*, which is commonly called *Platonic*, was a fiction of the later Platonists, unknown to the founder of the school: but any person who shall take the trouble to study the writings of Plato, will find abundant evidence that he really asserted a triad of divine hypostases, all concerned in the formation and government of the world. Thus in his 10th book of Laws, where he undertakes to prove the existence of a Deity in opposition to atheists, he ascends no higher in the demonstration than to the ψυχη or mundane soul, which he held to be the immediate and proper cause of all the motion that is in the world. But in other parts of his writings he frequently asserts, as superior to the self-moving principle, an immoveable νους or intellect, which was properly the *demiurgus* or framer of the world; and above this *hypostasis* one most simple and absolutely perfect being, who is considered in his *Theology* as αυτοθεος the *original deity*, in contradistinction from the others, who are only θεοι εκ θεου. These doctrines are to be gathered from his works at large, particularly from the *Timæus*, *Philebus*, *Sophista* and *Epinomis*: but there is a passage in his second epistle to Dionysius, apparently written in answer to a letter, in which that monarch had required him to give a more explicit account than he had formerly done of the nature of God, in which the doctrine of a Trinity seems to be directly asserted. "After having said that he meant to wrap up his meaning in such obscurity, as that an adept only should fully comprehend it, he adds expressions to the following import: 'The Lord of Nature is surrounded on all sides by his works: whatever is exists by his permission: he is the fountain and source of excellence: around the second person are placed things of the second order; and around the third those of the third degree (B).'" Of this obscure passage a very satisfactory explanation is given in Dr Ogilvie's *Theology of Plato*, to which the narrow limits prescribed to such articles as this compel us to refer the reader. We shall only say, that the account which we have given of the Platonic trinity is ably supported by the doctor.

In treating of the eternal emanation of the second and third hypostases from the first, the philosophers of the academy compare them to light and heat proceeding from the sun. Plato himself, as quoted by Dr Cudworth, illustrates his doctrine by the same comparison. For

(B). "Περι των παντων βασιλεα, παντ᾽ εςι, και Εκεινου ενεκα παντα. Εκεινος αιτια παντων των καλων. Δευτερον δε περι τα δευτερα, και τρετον περι τα τρετα. Oper. p. 1269.

Platoniſm.

For "τ'αγαθον or the firſt hypoſtaſis, is in the intellectual world the ſame (he ſays) to intellect and intelligibles that the ſun is in the corporeal world to viſion and viſibles; for as the ſun is not viſion itſelf but the cauſe of viſion, and as that light by which we ſee is not the ſun but only a thing like the ſun; ſo neither is the Supreme or Higheſt Good properly knowledge, but the cauſe of knowledge; nor is intellect, conſidered as ſuch, the beſt and moſt perfect being, but only a being having the form of perfection." Again, "as the ſun cauſes other things not only to become viſible but alſo to be generated; ſo the Supreme Good gives to things not only their capability of being known, but alſo their very eſſences by which they ſubſiſt; for this fountain of the Deity, this higheſt good, is not itſelf properly eſſence, but above eſſence, tranſcending it in reſpect both of dignity and of power."

The reſemblance which this trinity of Plato bears to that revealed in the goſpel muſt be obſerved by every attentive reader; but the two doctrines are likewiſe in ſome reſpects exceedingly diſſimilar. The third hypoſtaſis in the Platonic ſyſtem appears in no point of view co-ordinate with the firſt or ſecond. Indeed the firſt is elevated far above the ſecond, and the third ſunk ſtill farther beneath it, being conſidered as a mere ſoul immerſed in matter, and forming with the corporeal world, to which it is united, one compound animal. Nay, it does not appear perfectly clear, that Plato conſidered his ψυχη του κοσμου as a pure ſpirit, or as having ſubſiſted from eternity as a diſtinct *Hypoſtaſis*. "This governing ſpirit, of whom the earth, properly ſo called, is the body, conſiſted, according to our author's philoſophy, of the ſame and the other; that is, of the firſt matter, and of pure intelligence, framed to actuate the machinery of nature. The Supreme Being placed him in the middle of the earth; which, in the vivid idea of Plato, ſeemed itſelf to live, in conſequence of an influence that was felt in every part of it. From this ſeat his power is repreſented as being extended on all ſides to the utmoſt limit of the heavens; conferring life, and preſerving harmony in the various and complicated parts of the univerſe. Upon this being God is ſaid to have looked with peculiar complacency after having formed him as an image of himſelf, and to have given beauty and perfect proportion to the manſion which he was deſtined to occupy. According to the doctrine of Timæus, the Supreme Being ſtruck out from this original mind innumerable ſpirits of inferior order, endowed with principles of reaſon; and he committed to divinities of ſecondary rank the taſk of inveſting theſe in material forms, and of diſperſing them as inhabitants of the ſun, moon, and other celeſtial bodies. He taught alſo, that at death the human ſoul is reunited to the ψυχη του κοσμου, as to the ſource from which it originally came."

Such is the third perſon of the Platonic triad, as we find his nature and attributes very accurately ſtated by Dr Ogilvie; and the Chriſtian philoſopher, who has no particular ſyſtem to ſupport, will not require another proof that the triad of Plato differs exceedingly from the Trinity of the Scriptures. Indeed the third hypoſtaſis in this triad has ſo much the appearance of all that the ancients could mean by that which we call a *creature*, that the learned Cudworth, who wiſhed, it is difficult to conceive for what reaſon, to find the ſublimeſt myſtery of the Chriſtian faith explicitly taught in the writings of a pagan philoſopher, was forced to ſuppoſe that Plato held a double ψυχη, or ſoul, one εγκοσμιον, incorporated with the material world, and the other υπερκοσμιον or *ſupramundane*, which is not the ſoul but the governor of the univerſe. We call this a mere hypotheſis; for though the author diſplays vaſt erudition, and adduces many quotations in which this double *pſyche* is plainly mentioned, yet all thoſe quotations are taken from Platoniſts who lived after the propagation of the goſpel, and who, calling themſelves *eclectics*, freely ſtole from every ſect ſuch dogmas as they could incorporate with their own ſyſtem, and then attributed thoſe dogmas to their maſter. In the writings of Plato himſelf, there is not ſo much as an alluſion to this ſupramundane *pſyche* *; and it is for this reaſon (the ψυχη, of which he treats being ſo very inferior to the δημιουργος and αγαθον) that we have expreſſed with heſitation his belief of *three* hypoſtaſes in the divine nature. Yet that he did admit ſo many, ſeems more than probable both from the paſſage illuſtrated by Dr Ogilvie, and from the attempt of Plotinus, one of his followers, to demonſtrate that the number can be neither greater nor leſs. That his doctrine on this ſubject ſhould be inaccurate and erroneous, can excite no wonder; whilſt it muſt be confeſſed to have ſuch a reſemblance to the truth, and to be ſo incapable of being proved by reaſoning from effects to cauſes, that we could not doubt of his having inherited it by tradition, even though we had not complete evidence that ſomething very ſimilar to it was taught long before him, not only by Pythagoras and Parmenides, but by the philoſophers of the eaſt.

* *Moſch. ed. Cud. Syſt. Intel.* c. 4. § 36. n. 43.

We have ſaid that the Demiurgus was the maker of the world from the firſt matter which had exiſted from eternity; but in Plato's coſmogony there is another principle, more myſterious, if poſſible, than any thing which we have yet mentioned. This is his intellectual ſyſtem of *ideas*, which it is not eaſy to collect from his writings, whether he conſidered as *independent* exiſtences, or only as archetypal *forms*, which had ſubſiſted from eternity in the λογος or divine intellect. On this ſubject he writes with ſuch exceeding obſcurity, that men of the firſt eminence, both among the ancients and the moderns, have differed about his real meaning. Some have ſuppoſed, that by *ideas* he meant real beings ſubſiſting from eternity, independent of all minds, and ſeparate from all matter; and that of theſe ideas he conceived ſome to be living and others to be without life. In this manner his doctrine is interpreted by Tertullian * among the ancients, and by the celebrated Brucker † among the moderns; and not by them only, but by many others equally learned, candid, and acute. Cudworth, on the other hand, with his annotator Moſheim, contend, that by his ideal world Plato meant nothing more than that there exiſted from eternity in the λογος or mind of God a notion or conception of every thing which was in time to be made. This is certainly much more probable in itſelf, than that a man of enlarged underſtanding ſhould have ſuppoſed, that there are ſomewhere in extramundane ſpace real living incorporeal beings eating and drinking, which are the *ideas* of all the animals which ever have been or ever will be eating and drinking in this world. Yet Moſheim candidly acknowledges, that if the controverſy were to be decided by the votes of the learned, he is doubtful whether it would be given for or againſt him; and Cudworth, though he pleads

* *Lib. de Anima.*

† *Hiſtor. Doctrin. de Idæis.*

Platonism. pleads the cause of his master with much ingenuity, owns, that on this subject his language cannot be vindicated. This indeed is most true; for Plato contends, that his ideas are not only the objects of science, but also the proper or physical causes of all things here below; that the *idea* of similitude is the *cause* of the resemblance between two globes; and the *idea* of dissimilitude the cause that a globe does not resemble a pyramid: he likewise calls them ουσιας, *essences* or *substances*, and many of his followers have pronounced them to be *animals*.

These wonderful expressions incline us to adopt with some hesitation the opinion stated by Dr Enfield. This historian of philosophy having observed, that some of the admirers of Plato contend, that by ideas existing in the reason of God, nothing more is meant than conceptions formed in the Divine mind, controverts this opinion with much effect. "By ideas, Plato (says he) appears to have meant something much more mysterious; namely, patterns or archetypes subsisting by themselves, as real beings, οντως οντα in the Divine reason, as in their original and eternal region, and issuing thence to give form to sensible things, and to become objects of contemplation and science to rational beings. It is the doctrine of the Timæus, that ὁ λογισμος τȣ Θεȣ, the reason of God, comprehends exemplars of all things, and that this reason is one of the primary causes of things. Plutarch says, that Plato supposes three principles, God, Matter, and Idea. Justin Martyr, Pseudo-Origen, and others, assert the same thing.

"That this is the true Platonic doctrine of ideas will appear probable, if we attend to the manner in which Plato framed his system of opinions concerning the origin of things. 'Having been from his youth (says Aristotle) conversant with Cratylus, a disciple of Heraclitus, and instructed in the doctrine of that school, that all sensible things are variable, and cannot be proper objects of science, he reasonably concluded, that if there be any such thing as science, there must exist, besides sensible objects, certain permanent natures, perceptible only by the intellect.' Such natures, divine in their origin, and eternal and immutable in their existence, he admitted into his system, and called them *ideas*. Visible things were regarded by Plato as fleeting shades, and ideas as the only permanent substances. These he conceived to be the proper objects of science to a mind raised by divine contemplation above the perpetually varying scenes of the material world."

It was a fundamental doctrine in the system of Plato, that the Deity formed the material world after a perfect model, consisting of those ideas which had eternally subsisted in his own reason; and yet, with some appearance of contradiction, he calls this model "*self*-existent, indivisible, and eternally *generated*." Nay, he talks of it as being intelligent as well as eternal, and wholly different from the transcripts, which are subjected to our inspection. There is so much mystery, confusion, and apparent absurdity, in the whole of this system, as it has come down to us, that we must suppose the friends of Plato to have been entrusted with a key to his esoteric doctrines, which has long been lost, otherwise it would be difficult to conceive how that philosopher could have had so many admirers.

With almost every ancient theist of Greece the founder of the academy believed in an order of beings called *dæmons*, which were superior to the souls of men, and struck off by the Demiurgus from the soul of the world. Of these the reader will find some account elsewhere: (See DÆMON and POLYTHEISM). We mention them at present because they make an important appearance in Plato's system of physics, which was built upon them and upon the doctrine which has been stated concerning God, matter, and ideas. He taught, that the visible world was formed by the Supreme Architect, uniting eternal and immutable ideas to the first matter; that the universe is one animated being *, including within its limits all animated natures; that, in the formation of the visible and tangible world, fire and earth were first formed, and were afterwards united by means of air and water; that from perfect parts one perfect whole was produced, of a spherical figure, as most beautiful in itself, and best suited to contain all other figures †; that the elementary parts of the world are of regular geometrical forms, the particles of earth being cubical, those of fire pyramidical, those of air in the form of an octohedron, and those of water in that of an icosohedron; that these are adjusted in number, measure, and power, in perfect conformity to the geometrical laws of proportion; that the soul which pervades this sphere is the cause of its revolution round its centre; and, lastly, that the world will remain for ever, but that by the action of its animating principle, it accomplishes certain periods, within which every thing returns to its ancient place and state. This periodical revolution of nature is called the *Platonic* or *great year*. See the preceding article.

* *Timæus.*

† *Ibid.*

The metaphysical doctrines of Plato, which treat of the human soul, and the principles of his system of ethics, have been detailed in other articles (See METAPHYSICS, Part III. chap. iv.; and MORAL *Philosophy*, N° 6.): but it is worthy of observation in this place, that, preparatory to the study of all philosophy, he required from his disciples a knowledge of the elements of mathematics. In his Republic, he makes Glaucus, one of the speakers, recommend them for their usefulness in human life. "Arithmetic for accounts and distributions; geometry for encampments and mensurations; music for solemn festivals in honour of the gods; and astronomy for agriculture, for navigation, and the like. Socrates, on his part, denies not the truth of all this, but still insinuates that they were capable of answering an end more sublime. 'You are pleasant (says he) in your seeming to fear the multitude, lest you should be thought to enjoin certain sciences that are useless. 'Tis indeed no contemptible matter, though a difficult one, to believe, that through these particular sciences the soul has an organ purified and enlightened, which is destroyed and blinded by studies of other kinds; an organ better worth saving than a thousand eyes, in as much as *truth* becomes visible through *this alone*."

"Concerning policy, Plato has written at large in his Republic and in his Dialogue on Laws. He was so much enamoured with his own conceptions on this subject, that it was chiefly the hope of having an opportunity to realise his plan of a republic which induced him to visit the court of Dionysius. But they who are conversant with mankind, and capable of calmly investigating the springs of human actions, will easily perceive that his projects were chimerical, and could only have originated in a mind replete with philosophical enthusiasm. Of this nothing can be a clearer proof than the design of admitting in his republic a community of women, in order to give reason an entire controul over desire. The main object of his political institutions appears to have been, the subjugation of the passions and appetites, by means of the abstract contemplation of ideas. A system of policy, raised upon such fanciful grounds, cannot merit a more distinct consideration."

Such is genuine Platonism as it was taught in the old academy by the founder of the school and his immediate followers; but when Arcesilaus was placed at the head of the academics, great innovations were introduced both into their doctrines and into their mode of teaching (see ARCESILAUS). This man was therefore considered as the founder of what was afterwards called the *middle* academy. Being a professed sceptic, he carried his maxim of uncertainty to such a height, as to alarm the general body of philosophers, offend the governors of the state, and bring just odium upon the very name of the academy. At length *Carneades*, one of the disciples of this school, relinquishing some of the more obnoxious tenets of Arcesilaus, founded what has been called the *new* academy with very little improvement on the principles of the middle. See CARNEADES.

Under one or other of these forms Platonism found its way into the Roman republic. Cicero was a Platonist, and one of the greatest ornaments of the school. A school of Platonists was likewise founded in Alexandria in the second century of the Christian era; but their doctrines differed in many particulars from those taught in the three academies. They professed to seek truth wherever they could find it, and to collect their dogmas from every school. They endeavoured to bend some of the principles of Plato into a conformity with the doctrines of the gospel; and they incorporated with the whole many of the maxims of Aristotle and Zeno, and not a few of the fictions of the east. Their system was therefore extremely heterogeneous, and seldom so rational as that of the philosopher after whose name they were called, and of whose doctrines we have given so copious a detail. See AMMONIUS, ECCLECTICS, and PLOTINUS.

PLAUTUS, MARCUS ACCIUS, a comic writer of ancient Rome, born in Umbria, a province of Italy. His proper name was *Marcus Accius*, and he is supposed to have acquired the surname of *Plautus* from having splay feet. His parentage appears to have been mean; so that some have thought he was the son of a slave. Aulus Gellius says that Plautus was distinguished for his poetry on the theatre, and Cato for his eloquence in the forum, at the same time; and observes elsewhere from Varro, that he was so well paid for his plays as to double his stock in trading, in which he lost all he gained by the muses. He is said to have been reduced to work at a mill for his subsistence; but Varro adds, that his wit was his best support, as he composed three of his plays during this drudgery. He died in the first year of the elder Cato's censorship, about the year of Rome 569, and 184 before Christ. We have 20 of his plays extant, though not all of them entire. Five of them, comedies, have been elegantly translated into English by Mr B. Thornton, and published in 2 vols 8vo, 1767.

PLAYS. See the following article.

PLAYHOUSE. See THEATRE, AMPHITHEATRE, &c. The most ancient English playhouses were the Curtain in Shoreditch and the Theatre. In the time of Shakespeare, who commenced a dramatic writer in 1592, there were no less than 10 theatres open. Four of these were private houses, viz. that in Blackfriars, the Cockpit or Phœnix in Drury-Lane, a theatre in Whitefriars, and one in Salisbury court. The other six were called public theatres, viz. the Globe, the Swan, the Rose, and the Hope, on the Bank-side; the Red Bull, at the upper end of St John's street, and the Fortune in in White-cross street. The two last were chiefly frequented by citizens. Mr Malone gives us a pretty copious account of these playhouses, in a supplement to his last edition of Shakespeare, which we shall here insert.

"Most, if not all (says he) of Shakespeare's plays were performed either at the Globe or at the Theatre in Blackfriars. It appears that they both belonged to the same company of comedians, viz. his majesty's servants, which title they assumed, after a licence had been granted to them by King James in 1603, having before that time been called the servants of the lord chamberlain.

"The theatre in Blackfriars was a private house; but the peculiar and distinguishing marks of a private playhouse it is not easy to ascertain. It was very small, and plays were there usually represented by candle light. The Globe, situated on the southern side of the river Thames, was a hexagonal building, partly open to the weather, partly covered with reeds. It was a public theatre, and of considerable size, and there they always acted by daylight. On the roof of the Globe, and the other public theatres, a pole was erected, to which a flag was affixed. These flags were probably displayed only during the hours of exhibition; and it should seem from a passage in one of the old comedies that they were taken down during Lent, in which season no plays were presented. The Globe, though hexagonal at the outside, was probably a rotunda within, and perhaps had its name from its circular form. It might, however, have been denominated only from its sign, which was a figure of Hercules supporting the Globe. This theatre was burnt down in 1613, but it was rebuilt in the following year, and decorated with more ornament than had been originally bestowed upon it. The exhibitions at the Globe seem to have been calculated chiefly for the lower class of people; those at Blackfriars for a more select and judicious audience.

"A writer informs us, that one of these theatres was a winter and the other a summer house. As the Globe was partly exposed to the weather, and they acted there usually by daylight, it was probably the summer theatre. The exhibitions here seem to have been more frequent than at Blackfriars, at least till the year 1604 or 1605, when the Bank-side appears to have become less fashionable and less frequented than it formerly had been. Many of our ancient dramatic pieces were performed in the yards of carriers inns; in which, in the beginning of Queen Elizabeth's reign, the comedians, who then first united themselves in companies, erected an occasional stage. The form of these temporary playhouses seems to be preserved in our modern theatre. The galleries are in both ranged over each other on three sides of the building. The small rooms under the lowest of these galleries answer to our present boxes; and it is observable that these, even in theatres which were

Playhouse. were built in a subsequent period expresly for dramatic exhibitions, still retained their old name, and are frequently called rooms by our ancient writers. The yard bears a sufficient resemblance to the pit, as at present in use. We may suppose the stage to have been raised in this area, on the fourth side, with its back to the gateway of the inn, at which the money for admission was taken. Hence, in the middle of the Globe, and I suppose of the other public theatres, in the time of Shakespeare, there was an open yard or area, where the common people stood to see the exhibition; from which circumstance they are called by our author groundlings, and by Ben Johnson 'the understanding gentlemen of the ground.'

"In the ancient playhouses there appears to have been a private box, of which it is not easy to ascertain the situation. It seems to have been placed at the side of the stage towards the rear, and to have been at a lower price: in this some people sat, either from economy or singularity. The galleries, or scaffolds as they are sometimes called, and that part of the house which in private theatres was named the pit, seem to have been at the same price; and probably in houses of reputation, such as the Globe, and that in Blackfriars, the price of admission into those parts of the theatre was 6d. while in some meaner playhouses it was only 1d. in others only 2d. The price of admission into the best rooms or boxes was, I believe, in our author's time, 1s.; though afterwards it appears to have risen to 2s. and half-a-crown.

"From several passages in our old plays, we learn, that spectators were admitted on the stage, and that the critics and wits of the time usually sat there. Some were placed on the ground; others sat on stools, of which the price was either 6d. or 1s. according, I suppose, to the commodiousness of the situation; and they were attended by pages, who furnished them with pipes and tobacco, which was smoaked here as well as in other parts of the house: yet it should seem that persons were suffered to sit on the stage only in the private playhouses, such as Blackfriars, &c. where the audience was more select, and of a higher class; and that in the Globe and other public theatres no such licence was permitted.

"The stage was strewed with rushes, which, as we learn from Hentzner and Caius de Ephemera, was, in the time of Shakespeare, the usual covering of floors in England. The curtain which hangs in the front of the present stage, drawn up by lines and pulleys, though not a modern invention, for it was used by Inigo Jones in the masques at court, was yet an apparatus to which the simple mechanism of our ancient theatres had not arrived, for in them the curtains opened in the middle, and were drawn backwards and forwards on an iron rod. In some playhouses they were woollen, in others made of silk.—Towards the rear of the stage there appears to have been a balcony, the platform of which was probably eight or ten feet from the ground. I suppose it to have been supported by pillars. From hence, in many of our old plays, part of the dialogue was spoken; and in the front of this balcony curtains likewise were hung,

"A doubt has been entertained whether in our ancient theatres there were side and other scenes. The question is involved in so much obscurity, that it is very difficult to form any decided opinion upon it. It is certain, that in the year 1605 Inigo Jones exhibited an entertainment at Oxford, in which moveable scenes were used; but he appears to have introduced several pieces of machinery in the masques at court, with which undoubtedly the public theatres were unacquainted. A passage which has been produced from one of the old comedies, proves, it must be owned, that even these were furnished with some pieces of machinery, which were used when it was requisite to exhibit the descent of some god or saint; but from all the contemporary accounts, I am inclined to believe that the mechanism of our ancient stage seldom went beyond a painted chair or a trap-door, and that few, if any of them, had any moveable scenes. When King Henry VIII. is to be discovered by the dukes of Suffolk and Norfolk, reading in his study, the scenical direction in the first folio, 1623, which was printed apparently from playhouse copies), is, 'the king draws the curtain, (*i. e.* draws it open), and sits reading pensively;' for, besides the principal curtains that hung in the front of the stage, they used others as substitutes for scenes. If a bed-chamber is to be exhibited, no change of scene is mentioned; but the property-man is simply ordered to thrust forth a bed. When the fable requires the Roman capitol to be exhibited, we find two officers enter, 'to lay cushions, as it were, in the capitol,' &c. On the whole, it appears, that our ancient theatres, in general, were only furnished with curtains, and a single scene composed of tapestry, which were sometimes, perhaps, ornamented with pictures; and some passages in our old dramas incline one to think, that when tragedies were performed the stage was hung with black.

"In the early part, at least, of our author's* acquaintance with the theatre, the want of scenery seems to have been supplied by the simple expedient of writing the names of the different places where the scene was laid in the progress of the play, which were disposed in such a manner as to be visible to the audience. The invention of trap-doors, however, appears not to be modern; for in an old *morality*, intitled *All for Money*, we find a marginal direction which implies that they were very early in use. The covering, or internal roof of the stage, was anciently termed the heavens. It was probably painted of a sky-blue colour, or perhaps pieces of drapery tinged with blue were suspended across the stage to represent the heavens.

* *Shakespeare.*

"It is probable that the stage was formerly lighted by two large branches, of a form similar to those now hung in churches. They gave place in a subsequent period to small circular wooden frames, furnished with candles, eight of which were hung on the stage, four at either side, and these within a few years were wholly removed by Mr Garrick, who, on his return from France, first introduced the present commodious method of illuminating the stage by lights not visible to the audience. Many of the companies of players were formerly so thin, that one person played two or three parts; and a battle on which the fate of an empire was supposed to depend was decided by half a dozen combatants. It appears to have been a common practice in their mock engagements to discharge small pieces of ordnance on the stage. Before the exhibition began, three flourishes or pieces of music were played, or, in the ancient language, there were three soundings. Music was likewise played between the acts. The instruments chiefly used were trumpets, cornets, and hautboys.

Playhouse. hautboys. The band, which did not consist of more than five or six performers, sat in an upper balcony, over what is now called the stage-box.

"The person who spoke the prologue was ushered in by trumpets, and usually wore a long black velvet cloak, which, I suppose, was considered as best suited to a supplicatory address. Of this custom, whatever might have been its origin, some traces remained till very lately, a black coat having been, if I mistake not, within these few years, the constant stage-habiliment of our modern prologue-speakers. The dress of the ancient prologue-speaker is still retained in the play that is exhibited in Hamlet before the king and court of Denmark. The performers of male characters generally wore periwigs, which in the age of Shakespeare were not in common use. It appears, from a passage in Puttenham's *Art of English Poesy*, 1589, that vizards were on some occasions used by the actors of those days; and it may be inferred, from a scene in one of our author's comedies, that they were sometimes worn in his time by those who performed female characters; but this I imagine was very rare. Some of the female part of the audience likewise appeared in masks. The stage-dresses, it is reasonable to suppose, were much more costly at some theatres than at others; yet the wardrobe of even the king's servants at the Globe and Blackfriars, was, we find, but scantily furnished; and our author's dramas derived very little aid from the splendor of exhibition.

"It is well known, that in the time of Shakespeare, and for many years afterwards, female characters were represented by boys or young men. Sir William d'Avenant, in imitation of the foreign theatres, first introduced females in the scene, and Mrs Betterton is said to have been the first woman that appeared on the English stage. Andrew Pennycuike played the part of Matilda in a tragedy of Davenport's, in 1655; and Mr Kynaston acted several female parts after the Restoration. Downes, a contemporary of his, assures us, 'that being then very young he made a complete stage beauty, performing his parts so well, particularly Arthiope and Aglaura, that it has since been disputable among the judicious whether any woman that succeeded him touched the audience so sensibly as he.'

"Both the prompter, or book-holder, as he was sometimes called, and the property-man, appear to have been regular appendages of our ancient theatres. No writer that I have met with intimates, that in the time of Shakespeare it was customary to exhibit more than a single dramatic piece on one day. The Yorkshire tragedy, or *All's One*, indeed, appears to have been one of four pieces that were represented on the same day; and Fletcher has also a piece called *Four Plays in One;* but probably these were either exhibited on some particular occasion, or were ineffectual efforts to introduce a new species of amusement; for we do not find any other instances of the same kind. Had any shorter pieces been exhibited after the principal performance, some of them probably would have been printed: but there are none extant of an earlier date than the time of the Restoration. The practice, therefore, of exhibiting two dramas successively in the same evening, we may be assured was not established before that period. But though the audiences in the time of our author were not gratified by the representation of more than one drama in the same day, the entertainment was diversified, and the populace diverted, by vaulting, tumbling, slight of hand, and morris-dancing, a mixture not much more heterogeneous than that with which we are daily presented, a tragedy and a farce.

"The amusements of our ancestors, before the commencement of the play, were of various kinds, such as reading, playing at cards, drinking ale, or smoaking tobacco. It was a common practice to carry table-books to the theatre, and either from curiosity or enmity to the author, or some other motive, to write down passages of the play that was represented: and there is reason to believe that the imperfect and mutilated copies of some of Shakespeare's dramas, which are yet extant, were taken down in short-hand during the exhibition. At the end of the piece, the actors, in noblemen's houses and in taverns, where plays were frequently performed, prayed for the health and prosperity of their patrons; and in the public theatres for the king and queen. This prayer sometimes made part of the epilogue. Hence, probably, as Mr Steevens has observed, the addition of *Vivant rex et regina* to the modern play-bills.

"Plays, in the time of our author, began at one o'clock in the afternoon; and the exhibition was usually finished in two hours. Even in 1667 they commenced at three. When Gosson wrote his *School of Abuse*, in 1579, it seems the dramatic entertainments were usually exhibited on Sundays. Afterwards they were performed on that and other days indiscriminately. It appears from a contemporary writer, that exhibiting plays on Sunday had not been abolished in the third year of King Charles I.

"The modes of conveyance to the theatre, anciently as at present, seem to have been various; some going in coaches, others on horseback, and many by water.—To the Globe playhouse the company probably were conveyed by water; to that in Blackfriars the gentry went either in coaches or on horseback, and the common people on foot. In an epigram to Sir John Davis, the practice of riding to the theatre is ridiculed as a piece of affectation or vanity, and therefore we may presume it was not very general.

"The long and whimsical titles that are prefixed to the quarto copies of our author's plays, I suppose to have been transcribed from the play-bills of the time. A contemporary writer has preserved something like a play-bill of those days, which seems to corroborate this observation; for if it were divested of rhime, it would bear no very distant resemblance to the title pages that stand before some of our author's dramas:

" ——Prithee, what's the play?
" (The first I visited this twelvemonth day)
" They say " A new invented play of Purle,
" That jeoparded his neck to steal a girl
" Of twelve; and lying fast impounded for't,
" Has hither sent his beard to act his part;
" Against all those in open malice bent,
" That would not freely to the theft consent:
" Feigns all to's wish, and in the epilogue
" Goes out applauded for a famous rogue."
" —Now hang me if I did not look at first
" For some such stuff, by the fond people's thrust."

"It is uncertain at what time the usage of giving authors a benefit on the third day of the exhibition of their pieces commenced. Mr Oldys, in one of his manuscripts, intimates that dramatic poets had anciently their benefit on the first day that a new play was represented; a regulation

Playhouse. lation which would have been very favourable to some of the ephemeral productions of modern times. But for this there is not, I believe, any sufficient authority. From D'Avenant, indeed, we learn, that in the latter part of the reign of Queen Elizabeth the poet had his benefit on the second day. As it was a general practice in the time of Shakespeare to sell the copy of the play to the theatre, I imagine in such cases an author derived no other advantage from his piece than what arose from the sale of it. Sometimes, however, be found it more beneficial to retain the copyright in his own hands; and when he did so, I suppose he had a benefit. It is certain that the giving authors the profit of the third exhibition of their play, which seems to have been the usual mode during almost the whole of the last centnry, was an established custom in the year 1612, for Decker, in the prologue to one of his comedies printed in that year, speaks of the poet's third day. The unfortunate Otway had no more than one benefit on the production of a new play; and this too, it seems, he was sometimes forced to mortgage before the piece was acted. Southerne was the first dramatic writer who obtained the emoluments arising from two representations; and to Farquhar, in the year 1700, the benefit of a third was granted. When an author sold his piece to the sharers or proprietors of a theatre, it remained for several years unpublished; but when that was not the case, he printed it for sale, to which many seem to have been induced, from an apprehension that an imperfect copy might be issued from the press without their consent. The customary price of the copy of a play in the time of Shakespeare appears to have been twenty nobles, or six pounds thirteen shillings and four pence. The play when printed was sold for sixpence; and the usual present from a patron in return for a dedication was forty shillings. On the first day of exhibiting a new play, the prices of admission appear to have been raised; and this seems to have been occasionally practised on the benefit-nights of authors to the end of the last century. The custom of passing a final censure on plays at their first exhibition is as ancient as the time of our author; for no less than three plays of his rival Ben Jonson appear to have been damned; and Fletcher's Faithful Shepherdess, and The Knight of the Burning Pestle, written by him and Beaumont, underwent the same fate.

"It is not easy to ascertain what were the emoluments of a successful actor in the time of Shakespeare. They had not then annual benefits as at present. The performers at each theatre seem to have shared the profits arising either from each day's exhibition or from the whole season among them. From Ben Jonson's Poetaster we learn, that one of either the performers or proprietors had seven shares and a half; but of what integral sum is not mentioned. From the prices of admission into our ancient theatres, which have been already mentioned, I imagine the utmost that the sharers of the Globe playhouse could have received on any one day was about 35l. So lately as the year 1685, Shadwell received by his third day on the representation of the Squire of Alsatia, 130l.; which Downes the prompter says was the greatest receipt that had been ever taken at Drury-Lane playhouse at single prices. It appears from the MSS. of Lord Stanhope, treasurer of the chambers to King James I. that the customary sum paid to John Heminge and his company for the performance of a play at court was twenty nobles, or six pounds thirteen shillings and four pence. And Edward Alleyn mentions in his Diary, that he once had so slender an audience in his theatre called the *Fortune*, that the whole receipts of the house amounted to no more than three pounds and some odd shillings. Playhouse, Plea.

"Thus scanty and meagre were the apparatus and accommodations of our ancient theatres, on which those dramas were first exhibited, that have since engaged the attention of so many learned men, and delighted so many thousand spectators. Yet even then, we are told by a writer of that age, 'that dramatic poesy was so lively expressed and represented on the public stages and theatres of this city, as Rome in the age of her pomp and glory never saw it better performed; in respect of the action and art, not of the cost and sumptuousness."

PLEA, in *Law*, is what either party alleges for himself in court, in a cause there depending; and in a more restrained sense, it is the defendant's answer to the plaintiff's declaration.

Pleas are usually divided into these of the crown and common pleas. Pleas of the crown are all suits in the king's name, or in the name of the attorney-general in behalf of the king, for offences committed against his crown and dignity, and against his peace; as treason, murder, felony, &c. See ARRAIGNMENT.

Common pleas are such suits as are carried on between common persons in civil cases. These pleas are of two sorts; *dilatory* pleas, and pleas *to the action*. Dilatory pleas are such as tend merely to delay or put off the suit, by questioning the propriety of the remedy, rather than by denying the injury: pleas to the action are such as dispute the very cause of suit. *Blackst. Comment.*

I. *Dilatory* pleas are, 1. To the jurisdiction of the court: alleging, that it ought not to hold plea of this injury, it arising in Wales or beyond sea: or because the land in question is of ancient demesne, and ought only to be demanded in the lord's court, &c. 2. To the disability of the plaintiff, by reason whereof he is incapable to commence or continue the suit; as, that he is an alien enemy, outlawed, excommunicated, attainted of treason or felony, under a præmunire, not *in rerum natura* (being only a fictitious person), an infant, a feme-covert, or a monk professed. 3. In abatement: which abatement is either of the writ, or the count, for some defect in one of them; as by misnaming the defendant, which is called a *misnomer*; giving him a wrong addition, as esquire instead of knight; or other want of form in any material respect. Or, it may be that the plaintiff is dead; for the death of either party is at once an abatement of the suit.

These pleas to the jurisdiction, to the disability, or in abatement, were formerly very often used as mere dilatory pleas, without any foundation in truth, and calculated only for delay; but now by stat. 4 & 5 Ann. c. 16. no dilatory plea is to be admitted without affidavit made of the truth thereof, or some probable matter shown to the court to induce them to believe it true. And with respect to the pleas themselves, it is a rule, that no exception shall be admitted against a declaration or writ, unless the defendant will in the same plea give the plaintiff a better; that is, show him how it might be amended, that there may not be two objections upon the same account.

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All pleas to the jurisdiction conclude to the cognizance of the court; praying "judgement whether the court will have farther cognizance of the suit." Pleas to the disability conclude to the person; by praying "judgement, if the said A the plaintiff ought to be answered:" And pleas in abatement (when the suit is by original) conclude to the writ, or declaration; by praying "judgement of the writ, or declaration, and that the same may be quashed," *cassetur*, made void, or abated: but if the action be by bill, the plea must pray "judgement of the bill," and not of the declaration; the bill being here the original, and the declaration only a copy of the bill.

When these dilatory pleas are allowed, the cause is either dismissed from that jurisdiction, or the plaintiff is stayed till his disability be removed; or he is obliged to sue out a new writ, by leave obtained from the court, or to amend and new-frame his declaration. But when, on the other hand, they are overruled as frivolous, the defendant has judgement of *respondeat ouster*, or to answer over in some better manner. It is then incumbent on him to plead.

2. A plea *to the action*; that is, to answer to the merits of the complaint. This is done by confessing or denying it.

A confession of the whole complaint is not very usual; for then the defendant would probably end the matter sooner, or not plead at all, but suffer judgement to go by default. Yet sometimes, after tender and refusal of a debt, if the creditor harasses his debtor with an action, it then becomes necessary for the defendant to acknowledge the debt, and plead the tender; adding, that he has always been ready, *tout temps prist*, and is still ready, *uncore prist*, to discharge it: for a tender by the debtor and refusal by the creditor will in all cases discharge the costs, but not the debt itself; though in some particular cases the creditor will totally lose his money. But frequently the defendant confesses one part of the complaint (by a *cognovit actionem* in respect thereof), and traverses or denies the rest; in order to avoid the expence of carrying that part to a formal trial, which he has no ground to litigate. A species of this sort of confession is the *payment of money into court*: which is for the most part necessary upon pleading a tender, and is itself a kind of tender to the plaintiff; by paying into the hands of the proper officer of the court as much as the defendant acknowledges to be due, together with the costs hitherto incurred, in order to prevent the expence of any farther proceedings. This may be done upon what is called a *motion*; which is an occasional application to the court by the parties or their counsel, in order to obtain some rule or order of court, which becomes necessary in the progress of a cause: and it is usually grounded upon an *affidavit* (the perfect tense of the verb *affido*), being a vountary oath before some judge or officer of the court, to evince the truth of certain facts, upon which the motion is grounded: though no such affidavit is necessary for payment of money into court. If, after the money is paid in, the plaintiff proceeds in his suit, it is at his own peril: for if he does not prove more due than is so paid into court, he shall be nonsuited and pay the defendant's costs; but he shall still have the money so paid in, for that the defendant has acknowledged to be his due. To this head may also be referred the practice of what is called a *set off*; whereby the defendant acknowledges the justice of the plaintiff's demand on the one hand; but on the other, sets up a demand of his own, to counterbalance that of the plaintiff, either in the whole or in part; as, if the plaintiff sues for ten pounds due on a note of hand, the defendant may set off nine pounds due to himself for merchandise sold to the plaintiff; and, in case he plead such set-off, must pay the remaining balance into court.

Pleas that totally deny the cause of complaint are either the general issue, or a special plea in bar.

1. The *general issue*, or general plea, is what traverses, thwarts, and denies at once, the whole declaration, without offering any special matter whereby to evade it. As in trespass either *vi et armis*, or on the case, "*non culpabilis*, not guilty;" in debt upon contract, "*nihil debet*, he owes nothing;" in debt on bond, *non est factum*, it is not his deed;" on an *assumpsit*, "*non assumpsit*, he made no such promise." Or in real actions, "*nul tort*, no wrong done; *nul disseisin*, no disseisin;" and in a writ of right, the mise or issue is, that "the tenant has more right to hold than the demandant has to demand." These pleas are called the *general issue*, because, by importing an absolute and general denial of what is alleged in the declaration, they amount at once to an issue; by which we mean a fact affirmed on one side and denied on the other.

2. *Special* pleas in bar of the plaintiff's demands are very various, according to the circumstances of the defendant's case. As, in real actions, a general release or a fine; both of which may destroy and bar the plaintiff's title. Or, in personal actions, an accord, arbitration, conditions performed, nonage of the defendant, or some other fact which precludes the plaintiff from his action. A *justification* is likewise a special plea in bar; as in actions of assault and battery, *son assault demesne*, that it was the plantiff's own original assault; in trespass, that the defendant did the thing complained of in right of some office which warranted him so to do; or, in an action of slander, that the plaintiff is really as bad a man as the defendant said he was.

Also a man may plead the statutes of limitation in bar; or the time limited by certain acts of parliament, beyond which no plaintiff can lay his cause of action. This, by the statute of 32 Hen. VIII. c. 2. in a writ of right is 60 years: in assizes, writs of entry, or other possessory actions real, of the seisin of one's ancestors in lands; and either of their seisin, or one's own, in rents, suits, and services, 50 years: and in actions real for lands grounded upon one's own seisin or possession, such possession must have been within 30 years. By statute 1 Mar. st. 2. c. 5. this limitation does not extend to any suit for avowsons. But by the statute 21 Jac. I. c. 2. a time of limitation was extended to the case of the king; viz. 60 years precedent to 19th Feb. 1623; but, this becoming ineffectual by efflux of time, the same date of limitation was fixed by statute 9 Geo. III. c. 16. to commence and be reckoned backwards, from the time of bringing any suit or other process to recover the thing in question; so that a possession for 60 years is now a bar even against the prerogative, in derogation of the ancient maxim, *Nullum tempus occurrit regi.* By another statute, 21 Jac. I. c. 16. 20 years is the time of limitation in any writ of formedon: and, by a consequence, 20 years is also the limitation in every action of ejectment; for no ejectment can be brought, unless where

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where the lessor of the plantiff is entitled to enter on the lands. and by the statute 21 Jac. I. c. 16. no entry can be made by any man, unless within 20 years after his right shall accrue. Also all actions of trespass (*quare clausum fregit*, or otherwise), detinue, trover, replevin, account, and case (except upon accounts between merchants), debt on simple contract, or for arrears of rent, are limited by the statute last mentioned to six years after the cause of action commenced: and actions of assault, menace, battery, mayhem, and imprisonment, must be brought within four years, and actions for words two years, after the injury committed. And by the statute 31 Eliz. c. 5. all suits, indictments, and informations, upon any penal statutes, where any forfeiture is to the crown, shall be sued within two years, and where the forfeiture is to a subject, within one year, after the offence committed, unless where any other time is specially limited by the statute. Lastly, by statute 10 W. III. c. 14. no writ of error, *scire facias*, or other suit, shall be brought to reverse any judgement, fine, or recovery, for error, unless it be prosecuted within 20 years. The use of these statutes of limitation is to preserve the peace of the kingdom, and to prevent those innumerable perjuries which might ensue if a man were allowed to bring an action for any injury committed at any distance of time. Upon both these accounts the law therefore holds, that *interest reipublicæ ut sit finis litium*: and upon the same principle the Athenian laws in general prohibited all actions where the injury was committed five years before the complaint was made. If therefore, in any suit, the injury, or cause of action, happened earlier than the period expressly limited by law, the defendant may plead the statutes of limitations in bar: as upon an *assumpsit*, or promise to pay money to the plaintiff, the defendant may plead, *Non assumpsit infra sex annos*, He made no such promise within six years; which is an effectual bar to the complaint.

An *estoppel* is likewise a special plea in bar; which happens where a man hath done some act, or executed some deed, which estops or precludes him from averring any thing to the contrary. As if a tenant for years (who hath no freehold) levies a fine to another person. Though this is void as to strangers, yet it shall work as an estoppel to the cognizor; for, if he afterwards brings an action to recover these lands, and his fine is pleaded against him, he shall thereby be estopped from saying, that he had no freehold at the time, and therefore was incapable of levying it.

The conditions and qualities of a plea (which, as well as the doctrine of estoppels, will also hold equally, *mutatis mutandis*, with regard to other parts of pleading), are, 1. That it be single and containing only one matter; for duplicity begets confusion. But by statute 4 and 5 Ann. c. 16. a man, with leave of the court, may plead two or more distinct matters or single pleas; as in an action of assault and battery, these three, Not guilty, *son assault demesne*, and the statute of limitations. 2. That it be direct and positive, and not argumentative. 3. That it have convenient certainty of time, place, and persons. 4. That it answer the plaintiff's allegations in every material point. 5. That it be so pleaded as to be capable of trial.

Special pleas are usually in the affirmative, sometimes in the negative, but they always advance some new fact not mentioned in the declaration; and then they must be averred to be true in the common form:—"And this he is ready to verify."—This is not necessary in pleas of the general issue, those always containing a total denial of the facts before advanced by the other party, and therefore putting him upon the proof of them. See PLEADINGS.

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PLEA to Indictment, the defensive matter alleged by a criminal on his indictment; (see ARRAIGNMENT.) This is either, 1. A plea to the jurisdiction; 2. A demurrer; 3. A plea in abatement; 4. A special plea in bar; or, 5. The general issue.

Blackst. Comment.

I. A plea to the *jurisdiction*, is where an indictment is taken before a court that hath no cognizance of the offence; as if a man be indicted for a rape at the sheriff's tourn, or for treason at the quarter-sessions: in these or similar cases, he may except to the jurisdiction of the court, without answering at all to the crime alleged.

II. A *demurrer* to the indictment, is incident to criminal cases, as well as civil, when the fact as alleged is allowed to be true, but the prisoner joins issue upon some point of law in the indictment, by which he insists, that the fact, as stated, is no felony, treason, or whatever the crime is alleged to be. Thus, for instance, if a man be indicted for feloniously stealing a greyhound; which is an animal in which no valuable property can be had, and therefore it is not felony, but only a civil trespass to steal it; in this case the party indicted may demur to the indictment; denying it to be felony, though he confesses the act of taking it. Some have held, that if, on demurrer, the point of law be adjudged against the prisoner, he shall have judgement and execution, as if convicted by verdict. But this is denied by others, who hold, that in such case he shall be directed and received to plead the general issue, Not guilty, after a demurrer determined against him. Which appears the more reasonable, because it is clear, that if the prisoner freely discovers the fact in court, and refers it to the opinion of the court whether it be felony or no; and upon the fact thus shown, it appears to be felony, the court will not record the confession, but admit him afterwards to plead not guilty. And this seems to be a case of the same nature, being for the most part a mistake in point of law, and in the conduct of his pleading; and, though a man by mispleading may in some cases lose his property, yet the law will not suffer him by such niceties to lose his life. However, upon this doubt, demurrers to indictments are seldom used: since the same advantages may be taken upon a plea of not guilty; or afterwards, in arrest of judgement, when the verdict has established the fact.

III. A plea in *abatement* is principally for a *misnomer*, a wrong name, or a false addition to the prisoner. As, if James Allen, gentleman, is indicted by the name of *John Allen, esquire*, he may plead that he has the name of *James*, and not of *John*; and that he is a *gentleman*, and not an *esquire*. And, if either fact is found by a jury, then the indictment shall be abated, as writs or declarations may be in civil actions. But, in the end, there is little advantage accruing to the prisoner by means of these dilatory pleas; because, if the exception be allowed, a new bill of indictment may be framed, according to what the prisoner in his plea avers to be his true name and addition. For it is a rule, upon all pleas in abatement, that he who takes advantage of a flaw,

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must at the same time show how it may be amended. Let us therefore next consider a more substantial kind of plea, viz.

IV. Special pleas in *bar;* which go to the merits of the indictment, and give a reason why the prisoner ought not to answer it at all, nor put himself upon his trial for the crime alleged. These are of four kinds: a former acquittal, a former conviction, a former attainder, or a pardon. There are many other pleas which may be pleaded in bar of an appeal: but these are applicable to both appeals and indictments.

1. First, the plea of *auterfoits acquit*, or a former acquittal, is grounded on this universal maxim of the common law of England, that no man is to be brought into jeopardy of his life, more than once, for the same offence. And hence it is allowed as a consequence, that when a man is once fairly found not guilty upon any indictment, or other prosecution, before any court having competent jurisdiction of the offence, he may plead such acquittal in bar of any subsequent accusation for the same crime.

2. Secondly, the plea of *auterfoits convict*, or a former conviction for the same identical crime, though no judgement was ever given, or perhaps will be (being suspended by the benefit of clergy or other causes), is a good plea in bar to an indictment. And this depends upon the same principle as the former, that no man ought to be twice brought in danger of his life for one and the same crime.

3. Thirdly, the plea of *auterfoits attaint*, or a former attainder, is a good plea in bar, whether it be for the same or any other felony. For wherever a man is attainted of felony, by judgement of death either upon a verdict or confession, by outlawry, or heretofore by abjuration, and whether upon an appeal or an indictment; he may plead such attainder in bar to any subsequent indictment or appeal, for the same or for any other felony. And this because, generally, such proceeding on a second prosecution cannot be to any purpose; for the prisoner is dead in law by the first attainder, his blood is already corrupted, and he hath forfeited all that he had: so that it is absurd and superfluous to endeavour to attaint him a second time. Though to this general rule, as to all others, there are some exceptions; wherein, *cessante ratione, cessat et ipsa lex.*

4. Lastly, a pardon may be pleaded in bar; as at once destroying the end and purpose of the indictment, by remitting that punishment, which the prosecution is calculated to inflict. There is one advantage that attends pleading a pardon in bar, or in the arrest of judgement before sentence is past; which gives it by much the preference to pleading it after sentence or attainder. This is, that by stopping the judgement it stops the attainder, and prevents the corruption of the blood: which, when once corrupted by attainder, cannot afterwards be restored otherwise than by act of parliament.

V. The *general issue*, or plea of not guilty, upon which plea alone the prisoner can receive his final judgement of death. In case of an indictment of felony or treason, there can be no special justification put in by way of plea. As, on an indictment for murder, a man cannot plead that it was in his own defence against a robber on the highway, or a burglar; but he must plead the general issue, Not guilty, and give this special matter in evidence. For (besides that these pleas do in effect amount to the general issue; since, if true, the prisoner is most clearly not guilty) as the facts in treason are laid to be done *proditorie et contra ligeantiæ suæ debitum;* and, in felony, that the killing was done *felonice;* these charges, of a traiterous or felonious intent, are the points and very *gist* of the indictment, and must be answered directly, by the general negative, Not guilty; and the jury upon the evidence will take notice of any defensive matter, and give their verdict accordingly as effectually as if it were or could be specially pleaded. So that this is, upon all accounts, the most advantageous plea for the prisoner.

When the prisoner hath thus pleaded not guilty, *non culpabilis*, or *nient culpable:* which was formerly used to be abbreviated upon the minutes, thus, *Non* (or *nient*) *cul.* the clerk of the assize, or clerk of arraigns, on behalf of the crown, replies, that the prisoner is guilty, and that he is ready to prove him so. This is done by two monosyllables in the same spirit of abbreviation, (*cul. prit.:* which signifies first that the prisoner is guilty, (*cul. culpable*, or *culpabilis*); and then that the king is ready to prove him so, (*prit*, *præsto sum*, or *paratus, verificare*). By this replication the king and the prisoner are therefore at issue: for when the parties come to a fact which is affirmed on one side and denied on the other, then they are said to be at issue in point of fact: which is evidently the case here, in the plea of *non cul.* by the prisoner; and the replication of *cul.* by the clerk.

How the courts came to express a matter of this importance in so odd and obscure a manner, can hardly be pronounced with certainty. It may perhaps, however, be accounted for by supposing, that these were at first short notes, to help the memory of the clerk, and remind him what he was to reply; or else it was the short method of taking down in court, upon the minutes, the replication and averment; *cul. prit:* which afterwards the ignorance of succeeding clerks adopted for the very words to be by them spoken (A).

But however it may have arisen, the joining of issue seems to be clearly the meaning of this obscure expression; which has puzzled our most ingenious etymologists, and is commonly understood as if the clerk of the arraigns, immediately on plea pleaded, had fixed an opprobrious name on the prisoner, by asking him, "*culprit*, how wilt thou be tried?" for immediately upon issue joined it is inquired of the prisoner, by what trial he will make his innocence appear. This form has at present reference to appeals and approvements only, wherein the appellee has his choice, either to try the accusation by

BATTLE

(A) Of this ignorance we may see daily instances, in the abuse of two legal terms of ancient French: one the prologue to all proclamations, "*Oyez*, or Hear ye," which is generally pronounced, most unmeaningly, "O yes: the other, a more pardonable mistake, viz. when a jury are all sworn, the officer bids the crier number them, for which the word in law-French is, "*Countez;*" but we now hear it pronounced in very good English, "Count these."

Battle or by Jury. But upon indictments, since the abolition of Ordeal, there can be no other trial but by jury, *per pais*, or by the country: and therefore, if the prisoner refuses to put himself upon the inquest in the usual form, that is, to answer that he will be tried by God and the country, if a commoner; and, if a peer, by God and his peers; the indictment, if in treason, is taken *pro confesso*; and the prisoner, in cases of felony, is judged to stand mute, and, if he perseveres in his obstinacy, shall now be convicted of the felony.

When the prisoner has thus put himself upon his trial, the clerk answers in the humane language of the law, which always hopes that the party's innocence rather than his guilt may appear, "God send thee a good deliverance." And then they proceed, as soon as conveniently may be, to the trial. See the article Trial.

PLEADINGS, in *Law*, are the mutual altercations between the plaintiff and defendant, (see Suit, Writ, and Process). They form the third part or stage of a fact; and at present are set down and delivered into the proper office in writing, though formerly they were usually put in by their counsel *ore tenus*, or *viva voce*, in court, and then minuted down by the chief clerks or prothonotaries; whence, in our old law-French, the pleadings are frequently denominated the *parol*.

The first of these is the *declaration*, *narratio*, or *count*, anciently called the *tale*; in which the plaintiff sets forth his cause of complaint at length: being indeed only an amplification or exposition of the original writ upon which his action is founded, with the additional circumstances of time and place, when and where, the injury was committed.

In *local* actions, where possession of land is to be recovered, or damages for an actual trespass, or for waste, &c. affecting land, the plaintiff must lay his declaration, or declare his injury to have happened in the very county and place that it really did happen; but in *transitory* actions, for injuries that might have happened anywhere, as debt, detinue, slander, and the like, the plaintiff may declare in what county he pleases, and then the trial must be in that county in which the declaration is laid. Though, if the defendant will make affidavit that the cause of action, if any, arose not in that but another county, the court will direct a change of *the venue* or *visne* (that is, the *vicinia* or neighbourhood in which the injury is declared to be done), and will oblige the plaintiff to declare in the proper county. For the statute 6 Ric. II. c. 2. having ordered all writs to be laid in their proper counties, this, as the judges conceived, impowered them to change the *venue*, if required, and not to insist rigidly on abating the writ: which practice began in the reign of James I. And this power is discretionally exercised, so as not to cause but prevent a defect of justice. Therefore the court will not change the *venue* to any of the four northern counties previous to the spring circuit; because there the assises are holden only once a-year, at the time of summer circuit. And it will sometimes remove the *venue* from the proper jurisdiction (especially of the narrow and limited kind), upon a suggestion, duly supported, that a fair and impartial trial cannot be had therein.

It is generally usual, in actions upon the case, to set forth several cases, by different counts in the same declaration; so that if the plaintiff fails in the proof of one, he may succeed in another. As in an action on the case upon an assumpsit for goods sold and delivered, the plaintiff usually counts or declares, first, upon a settled and agreed price between him and the defendant; as, that they bargained for 20l.: and lest he should fail in the proof of this, he counts likewise upon a *quantum valebant*; that the defendant bought other goods, and agreed to pay him so much as they were reasonably worth: and then avers that they were worth other 20l. and so on in three or four different shapes; and at last concludes with declaring, that the defendant had refused to fulfil any of these agreements, whereby he is endamaged to such a value. And if he proves the case laid in any one of his counts, though he fails in the rest, he shall recover proportionable damages. This declaration always concludes with these words, "and thereupon he brings suit," &c. *inde producit sectam, &c.* By which words, *suit* or *secta* (*à sequendo*), were anciently understood the witnesses or followers of the plaintiff. For in former times, the law would not put the defendant to the trouble of answering the charge till the plaintiff had made out at least a probable case. But the actual production of the *suit*, *secta*, or *followers*, is now antiquated, and hath been totally disused, at least ever since the reign of Edward III. though the form of it still continues.

At the end of the declaration are added also the plaintiff's common pledges of prosecution, John Doe and Richard Roe; which, as we elsewhere observe, (see Writ), are now mere names of form; though formerly they were of use to answer to the king for the amercement of the plaintiff, in case he were nonsuited, barred of his action, or had a verdict and judgment against him. For if the plaintiff neglects to deliver a declaration for two terms after the defendant appears, or is guilty of other delays or defaults against the rules of law in any subsequent stage of the action, he is adjudged not to follow or pursue his remedy as he ought to do; and thereupon a *nonsuit*, or *non prosequitur*, is entered, and he is said to be *non-pros*'d. And for thus deserting his complaint, after making a false claim or complaint (*pro falso clamore suo*), he shall not only pay costs to the defendant, but is liable to be amerced to the king. A *retraxit* differs from a nonsuit, in that the one is negative and the other positive: the nonsuit is a default and neglect of the plaintiff, and therefore he is allowed to begin his suit again upon payment of costs; but a *retraxit* is an open and voluntary renunciation of his suit in court; and by this he for ever loses his action. A *discontinuance* is somewhat similar to a nonsuit; for when a plaintiff leaves a chasm in the proceedings of his cause, as by not-continuing the process regularly from day to day, and time to time, as he ought to do, the suit is discontinued, and the defendant is no longer bound to attend; but the plaintiff must begin again, by suing out a new original, usually paying costs to his antagonist.

When the plaintiff hath stated his case in the declaration, it is incumbent on the defendant, within a reasonable time, to make his defence, and put in a plea; or else the plaintiff will at once recover judgment by *default*, or *nihil dicit*, of the defendant.

Defence, in its true legal sense, signifies not a justification, protection, or guard, which is now its popular signification; but merely an *opposing* or *denial* (from the French verb *defendre*) of the truth or validity of the complaint.

Pleadings. complaint. It is the *conteſtatio litis* of the civilians: a general aſſertion that the plaintiff hath no ground of action; which aſſertion is afterwards extended and maintained in his plea.

Before defence made, if at all, cognizance of the ſuit muſt be claimed or demanded; when any perſon or body-corporate hath the franchiſe, not only of holding pleas within a particular limited juriſdiction, but alſo of the cognizance of pleas; and that either without any words excluſive of other courts, which intitles the lord of the franchiſe, whenever any ſuit that belongs to his juriſdiction is commenced in the courts at Weſtminſter, to demand the cognizance thereof; or with ſuch excluſive words, which alſo intitle the defendant to plead to the juriſdiction of the court. Upon this claim of cognizance, if allowed, all proceedings ſhall ceaſe in the ſuperior court, and the plaintiff is left at liberty to purſue his remedy in the ſpecial juriſdiction. As, when a ſcholar or other privileged perſon of the univerſities of Oxford or Cambridge is impleaded in the courts at Weſtminſter, for any cauſe of action whatſoever, unleſs upon a queſtion of freehold. In theſe caſes, by the charter of thoſe learned bodies, confirmed by act of parliament, the chancellor, or vice-chancellor, may put in a claim of cognizance; which, if made in due time and form, and with due proof of the facts alleged, is regularly allowed by the courts. It muſt be demanded before full defence is made or imparlance prayed; for theſe are a ſubmiſſion to the juriſdiction of the ſuperior court, and the delay is a *laches* in the lord of the franchiſe: and it will not be allowed if it occaſions a failure of juſtice, or if an action be brought againſt the perſon himſelf who claims the franchiſe, unleſs he hath alſo a power in ſuch caſe of making another judge.

After defence made, the defendant muſt put in his plea. But before he defends, if the ſuit is commenced by *capias* or *latitat*, without any ſpecial original, he is intitled to demand one *imparlance*, or *licentia loquendi;* and may, before he pleads, have more granted by conſent of the court, to ſee if he can end the matter amicably without farther ſuit, by talking with the plaintiff: a practice which is ſuppoſed to have ariſen from a principle of religion, in obedience to that precept of the goſpel, "agree with thine adverſary quickly, whilſt thou art *in the way* with him." And it may be obſerved, that this goſpel-precept has a plain reference to the Roman law of the twelve tables, which expreſsly directed the plaintiff and defendant to make up the matter while they were in the way, or going to the prætor;—*in via, rem uti pacent orato.* There are alſo many other previous ſteps which may be taken by a defendant before he puts in his plea. He may, in real actions, demand a view of the thing in queſtion, in order to aſcertain its identity and other circumſtances. He may crave *oyer* of the writ, or of the bond, or other ſpecialty upon which the action is brought; that is, to hear it read to him; the generality of defendants in the times of ancient ſimplicity being ſuppoſed incapable to read it themſelves: whereupon the whole is entered *verbatim* upon the record; and the defendant may take advantage of any condition, or other part of it, not ſtated in the plaintiff's declaration. In real actions alſo the tenant may pray in *aid*, or call for the aſſiſtance of another, to help him to plead, becauſe of the feebleneſs or imbecility of his own eſtate. Thus a tenant for life may pray in aid of him that hath the inheritance in remainder or reverſion; and an incumbent may pray in aid of the patron and ordinary; that is, that they ſhall be joined in the action, and help to defend the title. *Voucher* alſo is the calling in of ſome perſon to anſwer the action, that hath warranted the title to the tenant or defendant. This we ſtill make uſe of in the form of common recoveries, which are grounded on a writ of entry; a ſpecies of action that relies chiefly on the weakneſs of the tenant's title, who therefore vouches another perſon to warrant it. If the voucher appear, he is made defendant inſtead of the voucher; but if he afterwards makes default, recovery ſhall be had againſt the original defendant; and he ſhall recover an equivalent in value againſt the deficient vouchee. In aſſizes, indeed, where the principal queſtion is, whether the demandant or his anceſtors were or were not in poſſeſſion till the ouſter happened, and the title of the tenant is little (if at all) diſcuſſed, there no voucher is allowed; but the tenant may bring a writ of *warrantia chartæ* againſt the warrantor, to compel him to aſſiſt him with a good plea or defence, or elſe to render damages and the value of the land, if recovered againſt the tenant. In many real actions alſo, brought by or againſt an infant under the age of 21 years, and alſo in actions of debt brought againſt him, as heir to any deceaſed anceſtor, either party may ſuggeſt the nonage of the infant, and pray that the proceedings may be deferred till his full age, or, in our legal phraſe, that the infant may have his age, and that the *parol may demur*, that is, that the pleadings may be ſtaid; and then they ſhall not proceed till his full age, unleſs it be apparent that he cannot be prejudiced thereby. But by the ſtatutes of Weſtm. 1. 3 Edw. I. c. 46. and of Gloceſter, 6 Edw. I. c. 2. in writs of entry *ſur diſſeiſin* in ſome particular caſes, and in actions aunceſtrel brought by an infant, the parol ſhall not demur; otherwiſe he might be deforced of his whole property, and even want a maintenance, till he came of age. So likewiſe in a writ of dower the heir ſhall not have his age; for it is neceſſary that the widow's claim be immediately determined, elſe ſhe may want a preſent ſubſiſtence. Nor ſhall an infant patron have it in a *quare impedit*, ſince the law holds it neceſſary and expedient that the church be immediately filled.

When theſe proceedings are over, the defendant muſt then put in his excuſe or plea. See Plea.

It is a rule in pleading, that no man be allowed to plead ſpecially ſuch a plea as amounts only to the general iſſue, or a total denial of the charge; but in ſuch caſe he ſhall be driven to plead the general iſſue in terms, whereby the whole queſtion is referred to a jury. But if the defendant, in an aſſize or action of treſpaſs, be deſirous to refer the validity of his title to the court rather than the jury, he may ſtate his title ſpecially; and at the ſame time give colour to the plaintiff, or ſuppoſe him to have an appearance or colour of title, bad indeed in point of law, but of which the jury are not competent judges. As if his own true title is, that he claims by feoffment with livery from A, by force of which he entered on the lands in queſtion, he cannot plead this by itſelf, as it amounts to no more than the general iſſue, *nul tort, nul diſſeiſin*, in aſſize, or *not guilty* in an action of treſpaſs. But he may allege this ſpecially, provided he goes farther, and ſays, that the plaintiff claiming by colour of a prior deed of feoffment, without

out livery, entered; upon whom he entered; and may then refer himself tot he judgement of the court which of these two titles is the best in point of law.

When the plea of the defendant is thus put in, if it does not amount to an issue or total contradiction of the declaration, but only evades it, the plaintiff may plead again, and reply to the defendant's plea: Either traversing it, that is, totally denying it; as if, on an action of debt upon bond, the defendant pleads *solvit ad diem*, that he paid the money when due; here the plaintiff in his replication may totally traverse this plea, by denying that the defendant paid it: Or he may allege new matter in contradiction to the defendant's plea; as when the defendant pleads no award made, the plaintiff may reply, and set forth an actual award, and assign a breach: Or the replication may confess and avoid the plea, by some new matter or distinction, consistent with the plaintiff's former declaration; as in an action for trespassing upon land whereof the plaintiff is seized, if the defendant shows a title to the land by descent, and that therefore he had a right to enter, and gives colour to the plaintiff, the plaintiff may either traverse and totally deny the fact of the descent; or he may confess and avoid it, by replying, that true it is that such descent happened, but that since the descent the defendant himself demised the lands to the plaintiff for term of life. To the replication the defendant may *rejoin*, or put in an answer called a *rejoinder*. The plaintiff may answer the rejoinder by a *sur-rejoinder*; upon which the defendant may *rebut*, and the plaintiff answer him by a *sur-rebutter*. Which pleas, replications, rejoinders, sur-rejoinders, rebutters, and sur-rebutters, answer to the *exceptio*, *replicatio*, *duplicatio*, *triplicatio*, and *quadruplicatio*, of the Roman laws.

The whole of this process is denominated the *pleading*; in the several stages of which it must be carefully observed, not to depart or vary from the title or defence which the party has once insisted on. For this (which is called a *departure* in pleading) might occasion endless altercation. Therefore the replication must support the declaration, and the rejoinder must support the plea, without departing out of it. As in the case of pleading no award made in consequence of a bond of arbitration, to which the plaintiff replies, setting forth an actual award; now the defendant cannot rejoin that he hath performed this award, for such rejoinder would be an entire departure from his original plea, which alleged that no such award was made: therefore he has now no other choice, but to traverse the fact of the replication, or else to demur upon the law of it.

Again, all duplicity in pleading must be avoided. Every plea must be simple, entire, connected, and confined to one single point: it must never be entangled with a variety of distinct independent answers to the same matter; which must require as many different replies, and introduce a multitude of issues upon one and the same dispute. For this would often embarrass the jury, and sometimes the court itself, and at all events would greatly enhance the expence of the parties. Yet it frequently is expedient to plead in such a manner as to avoid any implied admission of a fact, which cannot with propriety or safety be positively affirmed or denied. And this may be done by what is called a *protestation*; whereby the party interposes an oblique allegation or denial of some fact, protesting (by the gerund, *protestando*) that such a matter does or does not exist; and at the same time avoiding a direct affirmation or denial. Sir Edward Coke hath defined a protestation (in the pithy dialect of that age) to be, "an exclusion of a conclusion." For the use of it is, to save the party from being concluded with respect to some fact or circumstance which cannot be directly affirmed or denied without falling into duplicity of pleading; and which yet, if he did not thus enter his protest, he might be deemed to have tacitly waved or admitted. Thus, while tenure in villainage subsisted, if a villain had brought an action against his lord, and the lord was inclined to try the merits of the demand, and at the same time to prevent any conclusion against himself that he had waved his signiory; he could not in this case both plead affirmatively that the plaintiff was his villain, and also take issue upon the demand; for then his plea would have been double, as the former alone would have been a good bar to the action: but he might have alleged the villainage of the plaintiff by way of protestation, and then have denied the demand. By this means the future vassalage of the plaintiff was saved to the defendant, in case the issue was found in his (the defendant's) favour; for the protestation prevented that conclusion which would otherwise have resulted from the rest of his defence, that he had enfranchised the plaintiff, since no villain could maintain a civil action against his lord. So also if a defendant, by way of inducement to the point of his defence, alleges (among other matters) a particular mode of seisin or tenure which the plaintiff is unwilling to admit, and yet desires to take issue on the principal point of the defence, he must deny the seisin or tenure by way of protestation, and then traverse the defensive matter. So, lastly, if an award be set forth by the plaintiff, and he can assign a breach in one part of it (viz. the non-payment of a sum of money), and yet is afraid to admit the performance of the rest of the award, or to aver in general a non-performance of any part of it, lest something should appear to have been performed; he may save to himself any advantage he might hereafter make of the general non-performance, by alleging that by protestation, he can plead only the non-payment of the money.

In any stage of the pleadings, when either side advances or affirms any new matter, he usually (as was said) avers it to be true; "and this he is ready to verify." On the other hand, when either side traverses or denies the facts pleaded by his antagonist, he usually tenders an *issue*, as it is called; the language of which is different according to the party by whom it is tendered: for if the traverse or denial comes from the defendant, the issue is tendered in this manner, "And of this he puts himself upon the country," thereby submitting himself to the judgement of his peers: but if the traverse lies upon the plaintiff, he tenders the issue or prays the judgement of the peers against the defendant in another form; thus, "and this he prays may be inquired of by the country."

But if either side (as, for instance, the defendant) pleads a special negative plea, not traversing or denying any thing that was before alleged, but disclosing some new negative matter; as where the suit is on a bond conditioned to perform an award, and the defendant pleads, negatively, that no award was made; he tenders no issue upon this plea, because it does not yet appear whether

Pleadings, Pleasure.

whether the fact will be disputed, the plaintiff not having yet asserted the existence of any award: but when the plaintiff replies, and sets forth an actual specific award, if then the defendant traverses the replication, and denies the making of any such award, he then, and not before, tenders an issue to the plaintiff. For when in the course of pleading they come to a point which is affirmed on one side and denied on the other, they are then said to be at issue; all their debates being at last contracted into a single point, which must now be determined either in favour of the plaintiff or of the defendant. See ISSUE.

PLEASING, art of. See POLITENESS.

PLEASURE is a word so universally understood as to need no explanation. Lexicographers, however, who must attempt to explain every word, call it "the gratification of the mind or senses." It is directly opposite to PAIN, and constitutes the whole of positive happiness, as that does of misery.

The Author of Nature has furnished us with many pleasures, as well as made us liable to many pains; and we are susceptible of both in some degree as soon as we have life and are endowed with the faculty of sensation. A French writer, in a work * which once raised high expectations, contends, that a child in the womb of its mother feels neither pleasure nor pain. "These sensations (says he) are not innate; they have their origin from without; and it is at the moment of our birth that the soul receives the first impressions; impressions slight and superficial at the beginning, but which by time and repeated acts leave deeper traces in the sensorium, and become more extensive and more lasting. It is when the child sends forth its first cries that sensibility or the faculty of sensation is produced, which in a short time gathers strength and stability by the impression of exterior objects. Pleasure and pain not being innate, and being only acquired in the same manner as the qualities which we derive from instruction, education, and society, it follows that we learn to suffer and enjoy as we learn any other science."

* *Encyclopedie Methodique, Logique, Metaphysique*, et *Morale*, tom. iv.

This is strange reasoning and strange language. That sensations are not innate is universally acknowledged; but it does not therefore follow that the soul receives its first impressions and first sensations at the moment of birth. The child has life, the power of locomotion, and the sense of touch, long before it is born; and every mother will tell this philosopher, that an infant unborn exhibits symptoms both of pain and of pleasure. That many of our organs of sense are improved by use is incontrovertible; but it is so far from being true that our sensible pleasures become more exquisite by being often repeated, that the direct contrary is experienced of far the greater part of them; and though external objects, by making repeated impressions on the senses, certainly leave deeper traces on the memory than an object once perceived can do, it by no means follows that these impressions become the more delightful the more familiar that they are to us. That we learn to suffer and enjoy as we learn any other science, is a most extravagant paradox; for it is self-evident that we cannot live without being capable in some degree both of suffering and enjoyment, though a man may certainly live to old age in profound ignorance of all the sciences.

The same writer assures us, indeed, that sensation is not necessary to human life. "Philosophers (says he) make mention of a man who had lost every kind of feeling in every member of his body: he was pinched or pricked to no purpose. Meanwhile this man made use of all his members; he walked without pain, he drank, ate, and slept, without perceiving that he did so. Sensible neither to pleasure nor pain, he was a true natural machine."

To the tale of these anonymous philosophers our author gives implicit credit, whilst he favours us at the same instant with the following argumentation, which completely proves its falsehood. "It is true that sensation is a relative quality, susceptible of increase and diminution; that it is not necessary to existence; and that one might live without it: but in this case he would live as an automaton, without feeling pleasure or pain; and he would possess neither idea, nor reflection, nor desire, nor passion, nor will, nor sentiment; his existence would be merely passive, he would live without knowing it, and die without apprehension."

But if this man of the philosophers, whom our author calls an *automaton*, and a *true natural machine*, had neither *idea*, nor *desire*, nor *passion*, nor *will*, nor *sentiment* (and without sensation he certainly could have none of them), what induced him to *walk*, *eat*, or *drink*, or to *cease* from any of these operations after they were accidentally begun? The instances of the *automata* which played on the flute and at chess are not to the purpose for which they are adduced; for there is no parallel between them and this natural machine, unless the philosophers wound up their man to eat, drink, walk, or sit, as Vacanson and Kempeler wound up their automata to play or cease from playing on the German flute and at chess. See ANDROIDES.

Our author having for a while sported with these harmless paradoxes, proceeds to put the credulity of his reader to the test with others of a very contrary tendency. He institutes an inquiry concerning the superiority, in number, and degree, of the pleasures enjoyed by the different orders of men in society; and labours, not indeed by argument, but by loose declamation, to propagate the belief that happiness is very unequally distributed. The pleasures of the rich, he says, must be more numerous and exquisite than those of the poor; the nobleman must have more enjoyments than the plebeian of equal wealth; and the king, according to him, must be the happiest of all men. He owns, indeed, that although "birth, rank, honours, and dignity, add to happiness, a man is not to be considered as miserable because he is born in the lower conditions of life. A man may be happy as a mechanic, a merchant, or a labourer, provided he enters into the spirit of his profession, and has not imbibed by a misplaced education those sentiments which make his condition insupportable. Happiness is of easy acquisition in the middling stations of life; and though perhaps we are unable to know or to rate exactly the pleasure which arises from contentment and mediocrity, yet happiness being a kind of aggregate of delights, of riches, and of advantages more or less great, every person must have a share of it; the division is not exactly made, but all other things equal, there will be more in the elevated than in the inferior conditions of society; the enjoyment will be more felt, the means of enjoying more multiplied, and the pleasures more varied. Birth, rank, fortune, talents, wit, genius,

Pleasure.

genius, and virtue, are then the great ſources of happineſs: thoſe advantages are ſo conſiderable, that we ſee men contented with any one of them, but their union forms ſupreme felicity.

"There is ſo vaſt a difference, ſays Voltaire, between a man who has made his fortune and one who has to make it, that they are ſcarcely to be conſidered as creatures of the ſame kind. The ſame thing may be ſaid of birth, the greateſt of all advantages in a large ſociety; of rank, of honours, and of great abilities. How great a difference is made between a perſon of high birth and a tradeſman; between a Newton or Deſcartes and a ſimple mathematician? Ten thouſand ſoldiers are killed on the field of battle, and it is ſcarcely mentioned; but if the general fall, and eſpecially if he be a man of courage and abilities, the court and city are filled with the news of his death, and the mourning is univerſal.

"Frederick the Great, king of Pruſſia, felt in a more lively manner than perhaps any other man the value of great talents. I would willingly renounce, ſaid he to Voltaire, every thing which is an object of deſire and ambition to man; but I am certain if I were not a prince I ſhould be nothing. Your merit alone would gain you the eſteem, and envy, and admiration of the world; but to ſecure reſpect for me, titles, and armies, and revenues, are abſolutely neceſſary."

For what purpoſe this account of human happineſs was publiſhed, it becomes not us to ſay. Its obvious tendency is to make the lower orders of ſociety diſcontented with their ſtate, and envious of their ſuperiors; and it is not unreaſonable to ſuppoſe, that it contributed in ſome degree to excite the ignorant part of the author's countrymen to the commiſſion of thoſe atrocities of which they have ſince been guilty. That ſuch was his intention, the following extract will not permit us to believe; for though in it the author attempts to ſupport the ſame falſe theory of human happineſs, he mentions virtuous kings with the reſpect becoming a loyal ſubject of the unfortunate Louis, whoſe character he ſeems to have intentionally drawn, and whoſe death by the authority of a ſavage faction he has in effect foretold.

"Happineſs, in a ſtate of ſociety, takes the moſt variable forms: it is a Proteus ſuſceptible of every kind of metamorphoſis: it is different in different men, in different ages, and in different conditions, &c. The pleaſures of youth are very different from thoſe of old age: what affords enjoyment to a mechanic would be ſupreme miſery to a nobleman; and the amuſements of the country would appear inſipid in the capital. Is there then nothing fixed with regard to happineſs? Is it of all things the moſt variable and the moſt arbitrary? Or, in judging of it, is it impoſſible to find a ſtandard by which we can determine the limits of the greateſt good to which man can arrive in the preſent ſtate? It is evident that men form the ſame ideas of the beautiful and ſublime in nature, and of right and wrong in morality, provided they have arrived at that degree of improvement and civilization of which human nature is ſuſceptible; and that different opinions on theſe ſubjects depend on different degrees of culture, of education, and of improvement. The ſame thing may be advanced with regard to happineſs: all men, if equal with reſpect to their organs, would form the very ſame ideas on this ſubject if they reached the degree of improvement of which we are preſently ſpeaking; and in fact, do we not ſee in the great circles at Rome, at Vienna, at London, and Paris, that thoſe who are called people of faſhion, who have received the ſame education, have nearly the ſame taſte, the ſame deſires, and the ſame ſpirit for enjoyment? there is doubtleſs a certain degree of happineſs to be enjoyed in every condition of life; but as there are ſome conditions preferable to others, ſo are there degrees of happineſs greater and leſs; and if we were to form an idea of the greateſt poſſible in the preſent ſtate, it perhaps would be that of a ſovereign, maſter of a great empire, enjoying good health and a moderate ſpirit; endowed with piety and virtue; whoſe whole life was employed in acts of juſtice and mercy, and who governed by fixed and immoveable laws. Such a king is the image of the divinity on earth, and he muſt be the idol of a wiſe people. His whole life ſhould preſent a picture of the moſt auguſt felicity. Although ſuch ſovereigns are rare, yet we are not without examples of them. Ancient hiſtory affords us Titus and Marcus Aurelius, and the preſent age can boaſt of piety and munificence in the character of ſome of its kings. This ſtate of the greateſt happineſs to which man can reach not being ideal, it will ſerve as a ſtandard of compariſon by which happineſs and miſery can be eſtimated in all civilized countries. *He is as happy as a king*, is a proverbial expreſſion, becauſe we believe with juſtice that royalty is the extreme limit of the greateſt enjoyments; and in fact, happineſs being the work of man, that condition which comprehends all the degrees of power and of glory, which is the ſource of honour and of dignity, and which ſuppoſes in the perſon inveſted with it all means of enjoyment either for himſelf or others, leaves nothing on this earth to which any reaſonable man would give the preference.

"We can find alſo in this high rank the extreme of the greateſt evils to which the condition of nature is expoſed. A king condemned to death and periſhing on a ſcaffold, by the authority of a faction, while at the ſame time he had endeavoured by every means in his power to promote the general happineſs of his ſubjects, is the moſt terrible and ſtriking example of human miſery; for if it be true that a crown is the greateſt of all bleſſings, then the loſs of it, and at the ſame time the loſs of life by an ignominious and unjuſt ſentence, are of all calamities the moſt dreadful.

"It is alſo in the courts of kings that we find the moſt amiable and perfect characters; and it is there where true grandeur, true politeneſs, the beſt tone of manners, the moſt amiable graces, and the moſt eminent virtues, are completely eſtabliſhed. It is in courts that men ſeem to have acquired their greateſt improvement: Whoſoever has ſeen a court, ſays La Bruyere, has ſeen the world in the moſt beautiful, the moſt enchanting, and attractive colours. The prejudices of mankind in behalf of the great are ſo exceſſive, that if they inclined to be good they would be almoſt the objects of adoration."

In this paſſage there are doubtleſs many juſt obſervations; but there is at leaſt an equal number of others both falſe and dangerous. That a crown is the greateſt of earthly bleſſings, and that it is in the courts of kings that we meet with the moſt amiable and perfect characters, are poſitions which a true philoſopher will not admit but with great limitations. The falſehood of the author's

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author's general theory respecting the unequal distribution of happiness in society, we need not waste time in exposing. It is sufficiently exposed in other articles of this work, and in one of them by a writer of a very superior order (See HAPPINESS; and *MORAL Philosophy*, Part II. chap. ii.). He enters upon other speculations respecting the pleasures and pains of savages, which are ingenious and worthy of attention; but before we proceed to notice them, it will be proper to consider the connection which subsists between pleasure and pain.

"That the cessation of pain is accompanied by pleasure, is a fact (says a philosopher of the first rank †) which has been repeatedly observed, but perhaps not sufficiently accounted for. Let us suppose a person in a state of indifference as to heat. Upon coming near a fire, he will experience at first an agreeable warmth, i. e. pleasure. If the heat be increased, this state of pleasure will, after a time, be converted into one of pain, from the increased action upon the nerves and brain, the undoubted organs of all bodily sensations. Let the heat now be gradually withdrawn, the nervous system must acquire again, during this removal, the state of agreeable warmth or pleasure; and after passing through that state it will arrive at indifference. From this fact then we may conclude, that a state of pleasure may be pushed on till it is converted into one of pain; and, on the other hand, that an action which produces pain will, if it go off gradually, induce at a certain period of its decrease a state of pleasure. The same reasoning which has thus been applied to the body may be extended also to the mind. Total languor of mind is not so pleasant as a certain degree of action or emotion; and emotions pleasant at one period may be increased till they become painful at another; whilst painful emotions, as they gradually expire, will, at a certain period of their decrease, induce a state of pleasure. Hence then we are able to explain why pleasure should arise in all cases from the gradual cessation of any action or emotion which produces pain."

† Dr Sayers.

The same author maintains, that from the mere removal of pain, whether by degrees or instantaneously, we always experience pleasure; and if the pain removed was exquisite, what he maintains is certainly true. To account for this phenomenon he lays down the following law of nature, which experience abundantly confirms, viz. "that the temporary withdrawing of any action from the body or mind invariably renders them more susceptible of that action when again produced." Thus, after long fasting, the body is more susceptible of the effects of food than if the stomach had been lately satisfied; the action of strong liquors is found to be greater on those who use them seldom than on such as are in the habit of drinking them. Thus, too, with respect to the mind; if a person be deprived for a time of his friend's society, or of a favourite amusement, the next visit of his friend, or the next renewal of his amusement, is attended with much more pleasure than if they had never been withheld from him.

"To apply this law to the case of a person suddenly relieved from acute pain. While he labours with such pain, his mind is so totally occupied by it, that he is unable to attend to his customary pursuits or amusements. He becomes therefore so much more susceptible of their action, that when they are again presented to him, he is raised above his usual indifference to positive pleasure. But all pains do not proceed from an excess of action. Many of them arise from reducing the body or the mind to a state below indifference. Thus, if a person have just sufficient warmth in his body to keep him barely at ease or in a state of indifference, by withdrawing this heat a state of uneasiness or pain is produced; and if in a calm state of mind one be made acquainted with a melancholy event, his quiet is interrupted, and he sinks below indifference into a painful state of mind. If now, without communicating any new source of positive pleasure, we remove in the former case the cold, and in the latter the grief, the persons from whom they are removed will experience real pleasure. Thus, then, whether pain arises from excess or deficiency of action, the gradual or the sudden removal of it must be in all cases attended with pleasure *." It is equally true that the gradual or sudden removal of pleasure is attended with pain.

* *Disquisitions Metaphysical and Literary.*

We are now prepared to examine our French author's account of the pleasures and pains of savages. "Every age (says he) has its different pleasures; but if we were to imagine that those of childhood are equal to those of confirmed age, we should be much mistaken in our estimation of happiness. The pleasures of philosophy, either natural or moral, are not unfolded to the infant; the most perfect music is a vain noise; the most exquisite perfumes and dishes highly seasoned offend his young organs instead of affording delight; his touch is imperfect; forty days elapse before the child gives any sign of laughter or of weeping; his cries and groans before that period are not accompanied with tears; his countenance expresses no passion; the parts of his face bear no relation to the sentiments of the soul, and are moreover without consistency. Children are but little affected with cold; whether it be that they feel less, or that the interior heat is greater than in adults. In them all the impressions of pleasure and pain are transitory; their memory has scarcely begun to unfold its powers; they enjoy nothing but the present moment; they weep, laugh, and give tones of satisfaction without consciousness, or at least without reflection; their joy is confined to the indulgence of their little whims, and constraint is the greatest of their misfortunes; few things amuse, and nothing satisfies them. In this happy condition of early infancy nature is at the whole expence of happiness; and the only point is not to contradict her. What desires have children? Give them liberty in all their movements, and they have a plenitude of existence, an abundance of that kind of happiness which is confined in some sort to all the objects which surround them: but if all beings were happy on the same conditions, society would be at no expence in procuring the happiness of the different individuals who compose it. Sensation is the foundation of reflection; it is the principal attribute of the soul; it is by this that man is elevated to sublime speculations, and secures his dominion over nature and himself. This quality is not stationary, but susceptible, like all other relative qualities, of increase and decay, of different degrees of strength and intenseness: it is different in different men; and in the same man it increases from infancy to youth, from youth to confirmed manhood: at this period it stops, and gradually declines as we proceed to old age and to second childishness. Considered physically, it varies according to age, constitution, climate, and food; considered in a moral point of of view, it takes its different appearances from individual education, and from the habits of society; for man in a state of nature and society, with regard to sensation and the unfolding of his powers, may be considered as two distinct beings: and if one were to make a calculation of pleasure in the course of human life, a man of fortune and capacity enjoys more than ten thousand savages.

"Pleasure and pain being relative qualities, they may be almost annihilated in the moment of vehement passion. In the heat of battle, for example, ardent and animated spirits have not felt the pain of their wounds; and minds strongly penetrated with sentiments of religion, enthusiasm, and humanity, have supported the most cruel torments with courage and fortitude. The sensibility of some persons is so exquisitely alive, that one can scarcely approach them without throwing them into convulsions. Many diseases show the effect of sensibility pushed to an extreme; such as hysteric affections, certain kinds of madness, and some of those which proceed from poison, and from the bite or sting of certain animals, as the viper and the tarantula. Excessive joy or grief, fear and terror, have been known to destroy all sensation, and occasion death (A)."

Having made these preliminary observations on pleasure and pain in infancy, and as they are increased or diminished by education, and the different conditions of body and mind, our author proceeds to consider the capability of savages to feel pleasure and pain. "By savages he understands all the tribes of men who live by hunting and fishing, and on those things which the earth yields without cultivation. Those tribes who possess herds of cattle, and who derive their subsistence from such possessions, are not to be considered as savages, as they have some idea of property. Some savages are naturally compassionate and humane, others are cruel and sanguinary. Although the physical constitution of man be everywhere the same, yet the varieties of climate, the abundance or scarcity of natural productions, have a powerful influence to determine the inclinations. Even the fierceness of the tiger is softened under a mild sky; now nature forms the manners of savages just as society and civil institutions form the manners of civilized life. In the one case climate and food produce almost the whole effect; in the other they have scarcely any influence. The habits of society every moment contend with nature, and they are almost always victorious. The savage devotes himself to the dominion of his passions; the civilized man is employed in restraining, in directing, and in modifying them: so much influence have government, laws, society, and the fear of censure and punishment, over his soul.

"It is not to be doubted that savages are susceptible both of pleasure and pain; but are the impressions made on their organs as sensible, or do they feel pain in the same degree with the inhabitants of a civilized country?

"Their enjoyments are so limited, that if we confine ourselves to truth, a few lines will be sufficient to describe them: our attention must therefore be confined to pain, because the manner in which they support misfortune, and even torture, presents us with a view of character unequalled in the history of civilized nations. It is not uncommon in civilized countries to see men braving death, meeting it with cheerfulness, and even not uttering complaints under the torture; but they do not insult the executioners of public vengeance, and defy pain in order to augment their torments; and those who are condemned by the laws suffer the punishment with different degrees of fortitude. On those mournful occasions, the common ranks of mankind in general die with less firmness: those, on the other hand, who have received education, and who, by a train of unfortunate events, are brought to the scaffold, whether it be the fear of being reproached with cowardice, or the consideration that the stroke is inevitable, such men discover the expiring sighs of self-love even in their last moments; and those especially of high rank, from their manners and sentiments, are expected to meet death with magnanimity: but an American savage in the moment of punishment appears to be more than human; he is a hero of the first order, who braves his tormentors, who provokes them to employ all their art, and who considers as his chief glory to bear the greatest degree of pain without shrinking (see AMERICA, N° 14, 27, 28, 29.). The recital of their tortures would appear exaggerated, if it were not attested by the best authority, and if the savage nations among whom those customs are established were not sufficiently known; but the excess of the cruelty is not so astonishing as the courage of the victim. The European exposed to sufferings of the same dreadful nature would rend heaven and earth with his piercing cries and horrible groans; the reward of martyrdom, the prospect of eternal life, could alone give him fortitude to endure such torments; but the savage is not animated with this exalted hope. What supports him then in scenes of so exquisite suffering? The feeling of shame, the fear of bringing reproach on his tribe, and giving a stain to his fellows never to be wiped away, are the only sentiments which influence the mind of a savage, and which always present to his imagination, animate him, support him, and lend him spirit and resolution. At the same time, however powerful those motives may be, they would not be alone sufficient, if the

(A) There are instances of persons who have died at the noise of thunder without being touched. A man frightened with the fall of a gallery in which he happened to be, was immediately seized with the black jaundice. M. le Cat mentions a young person on whom the insolence of another made such an impression, that his countenance became at first yellow, and then changed into black, in such a manner that in less than eight days he appeared to wear a mask of black velvet: he continued in this state for four months, without any other symptom of bad health or any pain. A sailor was so terrified in a storm, that his face sweated blood, which like ordinary sweat returned as it was wiped off. Stahl, whose testimony cannot be called in question, cites a similar case of a girl who had been frightened with soldiers. The excess of fear, according to many physicians, produces madness and epilepsy.

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the savage felt pain in the same degree with the European. Sensibility, as we have already observed, is increased by education; it is influenced by society, manners, laws, and government; climate and food work it into a hundred different shapes; and all the physical and moral causes contribute to increase and diminish it. The habitual existence of a savage would be a state of suffering to an inhabitant of Europe. You must cut the flesh of the one and tear it away with your nails, before you can make him feel in an equal degree to a scratch or prick of a needle in the other. The savage, doubtless, suffers under torture, but he suffers much less than an European in the same circumstances: the reason is obvious; the air which the savages breathe is loaded with fog and moist vapours; their rivers not being confined by high banks, are by the winds as well as in floods spread over the level fields, and deposit on them a putrid and pernicious slime; the trees squeezed one upon another, in that rude and uncultivated country serve rather as a covering to the earth than an ornament. Instead of those fresh and delicious shades, those openings in the woods, and walks crossing each other in all directions, which delight the traveller in the fine forests of France and Germany; those in America serve only to intercept the rays of the sun, and to prevent the benign influence of his beams. The savage participates of this cold humidity; his blood has little heat, his humours are gross, and his constitution phlegmatic. To the powerful influence of climate, it is necessary to join the habits of his life. Obliged to traverse vast deserts for subsistence, his body is accustomed to fatigue; food not nourishing, and at the same time in no great plenty, blunts his feelings; and all the hardships of the savage state give a rigidity to his members which makes him almost incapable of suffering. The savage in this state of nature may be compared to our water-women and street-porters, who, though they possess neither great vigour nor strength, are capable of performing daily, and without complaint, that kind of labour which to a man in a different condition of life would be a painful and grievous burden. Feeling, in less perfection with the savage, by the effects of climate and food, and the habits of his life, is still farther restrained by moral considerations. The European is less a man of nature than of society: moral restraints are powerful with him; while over the American they have scarcely any influence. This latter then is in a double condition of imperfection with regard to us; his senses are blunted, and his moral powers are not disclosed. Now, pleasure and pain depending on the perfection of the senses and the unfolding of the intellectual faculties, it cannot be doubted, that in enjoyments of any kind savages experience less pleasure, and in their suffering less pain, than Europeans in the same circumstances. And in fact, the savages of America possess a very feeble constitution. They are agile without being strong; and this agility depends more on their habits than on the perfection of their members: they owe it to the necessity of hunting; and they are moreover so weak, that they were unable to bear the toil which their first oppressors imposed on them. Hence a race of men in all respects so imperfect could not endure torment under which the most robust European would sink, if the pain which they feel were really as great as it appears to be. Feeling is then, and must necessarily be, less in the savage condition; for this faculty disclosing itself by the exercise of all the physical and moral qualities, must be less as they are less exercised. Every thing shows the imperfection of this precious quality, this source of all our affections, in the American savages.

"All the improvements in Europe have had a tendency to unfold sensibility: the air is purified that we may breathe more freely; the morasses are drained, the rivers are regulated in their courses, the food is nourishing, and the houses commodious. With the savages, on the contrary, every thing tends to curb it; they take pleasure even in hardening the organs of the body, in accustoming themselves to bear by degrees the most acute pain without complaining. Boys and girls among the savages amuse themselves with tying their naked arms together, and laying a kindled coal between them, to try which of them can longest suffer the heat; and the warriors who aspire to the honour of being chief, undergo a course of suffering which exceeds the idea of torture inflicted on the greatest criminals in Europe."

These observations on the pleasures and pains of savages appear to be well-founded, and, as the attentive reader will perceive, are perfectly agreeable to the theory of Dr Sayers. If indeed that theory be just, as we believe it to be, it will follow, that the few pleasures of sense which the American enjoys, he ought to enjoy more completely than any European, because to him they recur but seldom. This may very possibly be the case; and certainly would be so, were not his fibres, by climate and the habits of his life, rendered more rigid than those of the civilized part of the inhabitants of Europe. But if we agree with our author * in what he says of the pains and pleasures of savages, we cannot admit, without many exceptions, his theory of the enjoyments of children. It is so far from being true, that few things amuse, and that nothing satisfies them, that the direct contrary must have been observed by every man attentive to the operations of the infant mind, which is amused with every thing new, and often completely satisfied with the merest trifle. The pleasures of philosophy are not indeed unfolded to the infant; but it by no means follows that he does not enjoy his rattle and his drum as much as the philosopher enjoys his telescope and air-pump; and if there be any truth in the science of physiognomy, the happiness of the former is much more pure and exquisite than that of the latter. That the most perfect music is vain noise to an infant, is far from being self-evident, unless the author confines the state of infancy to a very few months; and we are not disposed to believe, without better proof than we have yet received, that the relish of exquisite perfumes and highly-seasoned dishes adds much to the sum of human felicity.

* *Encyclopedie Methodique, Logique, Metaphysique, et Morale*, tom. iv.

But however much we disapprove of many of these reflections, the following we cordially adopt as our own. "If we compare (says our author) the pleasures of sense with those which are purely intellectual, we shall find that the latter are infinitely superior to the former, as they may be enjoyed at all times and in every situation of life. What are the pleasures of the table, says Cicero, of gaming, and of women, compared with the delights of study? This taste increases with age, and no happiness

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happineſs is equal to it. Without knowledge and ſtudy, ſays Cato, life is almoſt the image of death (B). The pleaſures of the ſoul are ſuch, that it is frequent enough to ſee men preſerve their gaiety during their whole life, notwithſtanding a weak, diſeaſed, and debilitated body. Scaron, who lived in the laſt century, was an example of this. Balzac, ſpeaking of him, ſays, that Prometheus, Hercules, and Philoctetes, in profane, and Job in ſacred, hiſtory, ſaid many great things while they were afflicted with violent pain; but Scaron alone ſaid pleaſant things. I have ſeen, continues he, in many places of ancient hiſtory, conſtancy, and modeſty, and wiſdom, and eloquence, accompanying affliction; but he is the only inſtance wherein I have ſeen pleaſantry.

"There are men whoſe underſtandings are conſtantly on the ſtretch, and by this very means they are improved; but if the body were as conſtantly employed in the purſuit of ſenſual gratification, the conſtitution would ſoon be deſtroyed. The more we employ the mind we are capable of the greater exertion; but the more we employ the body we require the greater repoſe. There are beſides but ſome parts of the body capable of enjoying pleaſure; every part of it can experience pain. A toothach occaſions more ſuffering than the moſt conſiderable of our pleaſures can procure of enjoyment. Great pain may continue for any length of time; exceſſive pleaſures are almoſt momentary. Pleaſure carried to an extreme becomes painful; but pain, either by augmenting or diminiſhing it, never becomes agreeable. For the moment, the pleaſures of the ſenſes are perhaps more ſatisfactory; but in point of duration thoſe of the heart and mind are infinitely preferable. All the ſentiments of tenderneſs, of friendſhip, of gratitude, and of generoſity, are ſources of enjoyment for man in a ſtate of civilization. The damned are exceedingly unhappy, ſaid St Catherine de Sienna, if they are incapable of loving or being beloved.

"Pleaſure, continued for a great length of time, produces languor and fatigue, and excites ſleep; the continuation of pain is productive of none of theſe effects. Many ſuffer pain for eight days and even a month without interruption; an equal duration of exceſſive pleaſure would occaſion death.

"Time is a mere relative idea with regard to pleaſure and pain; it appears long when we ſuffer, and ſhort when we enjoy. If there exiſted no regular and uniform movement in nature, we would not be able from our ſenſations alone to meaſure time with any degree of exactneſs, for pain lengthens and pleaſure abridges it. From the languor of unoccupied time has ariſen the proverb expreſſive of our deſire to *kill* it. It is a melancholy reflection, and at the ſame time true, that there is no enjoyment which can effectually ſecure us from pain for the remainder of our lives; while there are examples of evils which hold men in conſtant ſorrow and pain during their whole exiſtence. Such then is the imperfection of the one and the power of the other.

"Pleaſure and pain are the ſources of morality; an action is juſt or unjuſt, good or otherwiſe, only as its natural tendency is to produce ſuffering or enjoyment to mankind. No crime could be committed againſt a being altogether inſenſible, nor could any good be beſtowed on it. Unleſs he were endowed with the deſire of pleaſure and the apprehenſion of pain, man, like an automaton, would act from neceſſity, without choice and without determination.

"All our paſſions are the developement of ſenſibility. If we were not poſſeſſed of feeling, we ſhould be deſtitute of paſſions; and as ſenſibility is augmented by civilization, the paſſions are multiplied; more active and vigorous in an extenſive and civilized empire than in a ſmall ſtate; more in the latter than among barbarous nations; and more in theſe laſt than among ſavages (ſee PASSION). There are more paſſions in France and England than in all the nations of Europe; becauſe every thing which ſerves to excite and foſter them is always in thoſe countries in the greateſt ſtate of fermentation. The mind is active; the ideas great, extenſive, and multiplied. And is it not the ſoul, the mind, and heart, which are the focus of all the paſſions?"

But wherever the paſſions are multiplied, the ſources of pleaſure and pain are multiplied with them. This being the caſe, it is impoſſible to preſcribe a fixed and general rule of happineſs ſuited to every individual. There are objects of pleaſure with regard to which all men of a certain education are agreed; but there are perhaps many more, owing to the variety of tempers and education, about which they differ. Every man forms ideas of enjoyment relative to his character; and what pleaſes one may be utterly deteſted by another. In proportion as a nation is civilized and extenſive, thoſe differences are remarkable. Savages, who are not acquainted with all the variety of European pleaſures, amuſe themſelves with very few objects. Owing to the want of civilization, they have ſcarcely any choice in the objects of taſte. They have few paſſions; we have many. But even in the nations of Europe pleaſure is infinitely varied in its modification and forms. Thoſe differences ariſe from manners, from governments, from political and religious cuſtoms, and chiefly from education. Meanwhile, however different and variable the ideas of pleaſure may be among nations and individuals, it ſtill remains a fact, that a certain number of perſons in all civilized ſtates, whether diſtinguiſhed by birth, or rank, or fortune, or talents, as they have nearly the ſame education ſo they form nearly the ſame ideas of happineſs: but to poſſeſs it a man muſt give his chief application to the ſtate of his mind; and notwithſtanding all his efforts it is of uncertain duration. Happineſs is the ſunſhine of life: we enjoy it frequently at great intervals; and it is therefore neceſſary to know how to uſe

(B) "Savages, barbarians, and peaſants, enjoy little happineſs except that of ſenſation, The happineſs of a civilized and well-informed man conſiſts of ſenſations, of ideas, and of a great number of affinities, altogether unknown to them. He not only enjoys the preſent, but the paſt and the future. He recals the agreeable idea of pleaſures which he has taſted. It is great happineſs, ſays an ancient, to have the recollection of good actions, of an upright intention, and of promiſes which we have kept."

use it. All the productions of art perish; the largest fortunes are dissipated; rank, honour, and dignity pass away like a fleeting shadow; the memory is impaired; all the faculties of the soul are extinguished; the body sinks under the infirmities of old age; and scarcely has one reached the boundaries of happiness marked out by his imagination, when he must give place to another, and renounce all his pleasures, all his hopes, all his illusions; the fugitive images of which had given happiness to the mind.

There are pleasures, however, on which the mind may securely rest, which elevate man above himself, dignify his nature, fix his attention on spiritual things, and render him worthy of the care of Providence. These are to be found in true religion; which procures for those who practise its duties inexpressible happiness in a better country, and is in this world the support of the weak, and the sweet consolation of the unfortunate.

PLEBEIAN, any person of the rank of the common people. It is chiefly used in speaking of the ancient Romans, who were divided into senators, patricians, and plebeians. The distinction was made by Romulus the founder of the city; who confined all dignities, civil, military, and sacerdotal, to the rank of patricians. But to prevent the seditions which such a distinction might produce through the pride of the higher order and the envy of the lower, he endeavoured to engage them to one another by reciprocal ties and obligations. Every plebeian was allowed to choose, out of the body of the patricians, a protector, who should be obliged to assist him with his interest and substance, and to defend him from oppression. These protectors were called *patrons;* the protected, *clients*. It was the duty of the patron to draw up the contracts of the clients, to extricate them out of their difficulties and perplexities, and to guard their ignorance against the artfulness of the crafty. On the other hand, if the patron was poor, his clients were obliged to contribute to the portions of his daughters, the payment of his debts, and the ransom of him and his children if they happened to be taken in war. The client and patron could neither accuse nor bear witness against each other; and if either of them was convicted of having violated this law, the crime was equal to that of treason, and any one might with impunity slay the offender as a victim devoted to Pluto and the infernal gods. For more than 600 years we find no dissensions or jealousies between the patrons and their clients; not even in the times of the republic, when the people frequently mutinied against the great and powerful.

PLECTRANTHUS, a genus of plants belonging to the didynamia class; and in the natural method ranking under the 42d order, *Verticillatæ*. See BOTANY *Index*.

PLEDGE (*Plegius*), in common law, a surety or gage, either real or personal, which the plaintiff or demandant is to find for his prosecuting the suit.

The word is sometimes also used for *FRANK Pledge*, which see.

To PLEDGE, in drinking, denotes to warrant, or be surety to one, that he shall receive no harm while he is taking his draught. The phrase is referred by antiquaries to the practice of the Danes heretofore in England, who frequently used to stab or cut the throats of the natives while they were drinking.

PLEDGES of Goods for money. See PAWN.

PLEDGERY, or PLEGGERY, in *Law*, suretiship, or an undertaking or answering for another.

PLEDGET, BOLSTER, or *Compress*, in *Surgery*, a kind of flat tent laid over a wound, to imbibe the superfluous humours, and to keep it clean.

PLEIADES, in fabulous history, the seven daughters of Atlas king of Mauritania and Pleione, were thus called from their mother. They were Maia, Electra, Taygete, Asterope, Merope, Halcyone, and Celœno; and were also called *Atlantides*, from their father Atlas. These princesses were carried off by Busiris king of Egypt; but Hercules having conquered him, delivered them to their father: yet they afterwards suffered a new persecution from Orion, who pursued them five years, till Jove, being prevailed on by their prayers, took them up into the heavens, where they form the constellation which bears their name.

PLEIADES, in *Astronomy*, an assemblage of seven stars, in the neck of the constellation Taurus.

They are thus called from the Greek πλειν, *navigare*, "to sail;" as being terrible to mariners, by reason of the rains and storms that frequently rise with them. The Latins called them *vergiliæ*, from *ver*, "spring;" because of their rising about the time of the vernal equinox. The largest is of the third magnitude, and is called *lucida pleiadum*.

PLENARY, something complete or full. Thus we say the pope grants *plenary* indulgences; i. e. full and entire remissions of the penalties due to all sins. See INDULGENCES.

PLENIPOTENTIARY, a person vested with full power to do any thing. See AMBASSADOR.

PLENITUDE, the quality of a thing that is full, or that fills another. In medicine, it chiefly denotes a redundancy of blood and humours.

PLENUM, in *Physics*, denotes, according to the Cartesians, that state of things wherein every part of space is supposed to be full of matter, in opposition to a VACUUM, which is a space supposed devoid of all matter.

PLENUS FLOS, a full flower; a term expressive of the highest degree of luxuriance in flowers. See BOTANY. Such flowers, although the most delightful to the eye, are both vegetable monsters, and, according to the sexualists, vegetable eunuchs; the unnatural increase of the petals constituting the first; the consequent exclusion of the stamina or male organs, the latter. The following are well-known examples of flowers with more petals than one; ranunculus, anemone, marsh-marygold, columbine, fennel-flower, poppy, pæony, pink, gilliflower, campion, viscous campion, lily, crown imperial, tulip, narcissus, rocket, mallow, Syrian mallow, apple, pear, peach, cherry, almond, myrtle, rose, and strawberry.

Flowers with one petal are not so subject to fullness. The following, however, are instances: polyanthus, hyacinth, primrose, crocus, meadow-saffron, and thorn-apple; though Kramer has asserted that a full flower with one petal is a contradiction in terms. In flowers with one petal, the mode of luxuriance, or impletion, is by a multiplication of the divisions of the limb or upper part; in flowers with more petals than one, by a multiplication of the petals or nectarium.

To take a few examples. Columbine is rendered full in in three different ways: 1. By the multiplication of its petals, and total exclusion of the nectaria; 2. By the multiplication of the nectaria, and exclusion of the petals; or, 3. By such an increase of the nectaria only as does not exclude the petals, between each of which are interjected three nectaria, placed one within another. Again, fennel-flower is rendered full by an increase of the nectaria only; narcissus, either by a multiplication of its cup and petals, or of its cup only; larkspur commonly by an increase of the petals and exclusion of the spur, which is its nectarium. In *saponaria concava anglia*, the impletion is attended with the singular effect of incorporating the petals, and reducing their number from five to one; and in gelder-rose, the luxuriance is effected by an increase both in magnitude and number of the circumference or margin of the head of flowers, in the plain, wheel-shaped, barren florets; and an exclusion of all the bell-shaped hermaphrodite florets of the centre or disk.

Hitherto we have treated of plenitude in simple flowers only: the instance just now adduced seems to connect the different modes of impletion in them and compound flowers. Before proceeding farther, however, it will not be improper to premise, that as a simple luxuriant flower is frequently, by beginners, mistaken for a compound flower in a natural state, such flowers may always be distinguished with certainty by this rule: That in simple flowers, however luxuriant, there is but one pistillum or female organ; whereas in compound flowers, each floret, or partial flower, is furnished with its own proper pistillum. Thus in hawk-weed, a compound flower, each flat or tongue-shaped floret in the aggregate has its five stamina and naked seed, which last is in effect its pistillum; whereas, in a luxuriant lychnis, which is a simple flower, there is found only one pistillum or female organ common to the whole.

In a compound radiated flower, which generally consists of plain florets in the margin or radius, and tubular or hollow florets in the centre or disc, plenitude is effected either by an increase of the florets in the margin, and a total exclusion of those in the disc; which mode of luxuriance is termed *impletion by the radius*, and resembles what happens in the gelder-rose: or by an elongation of the hollow florets in the centre, and a less profound division of their brims; which is termed *impletion by the disc*. In the first mode of luxuriance, the florets in the centre, which are always hermaphrodite or male, are entirely excluded; and in their place succeed florets similar in sex to those of the radius. Now as the florets in the margin of a radiated compound flower are found to be always either female, that is, furnished with the pistillum only; or neuter, that is, furnished with neither stamina nor pistillum; it is evident, that a radiated compound flower, filled by the radius, will either be entirely female, as in feverfew, daisy, and African marigold; or entirely neuter, as in sun-flower, marygold, and centaury: hence it will always be easy to distinguish such a luxuriant flower from a compound flower with plain florets in a natural state; as these flowers are all hermaphrodite, that is, furnished with both stamina and pistillum. Thus the full flowers of African marigold have each floret furnished with the pistillum or female organ only: the natural flowers of dandelion, which, like the former, is composed of plain florets, are furnished with both stamina and pistillum.

In the second mode of luxuriance, termed *impletion by the disc*, the florets in the margin sometimes remain unchanged: but most commonly adopt the figure of those in the centre, without, however, suffering any alteration in point of sex; so that confusion is less to be apprehended from this mode of luxuriance than from the former; besides, the length to which the florets in the centre run out is of itself a sufficient distinction, and adapted to excite at once an idea of luxuriance. Daisy, feverfew, and African marigold, exhibit instances of this as well as of the former mode of impletion.

In luxuriant compound flowers with plain florets, the *semiflosculosi* of Tournefort, the stigma or summit of the style in each floret is lengthened, and the seed-buds are enlarged and diverge; by which characters such flowers may always be distinguished from flowers of the same kind in a natural state. Scorzonera, nipple-wort, and goat's-beard, furnish frequent instances of the plenitude alluded to.

Lastly, the impletion of compound flowers with tubular or hollow florets, the *flosculosi* of Tournefort, seems to observe the same rules as that of radiated flowers just delivered. In everlasting-flower, the *xeranthemum* of Linnæus, the impletion is singular, being effected by the enlargement and expansion of the inward chaffy scales of the calyx. These scales, which become coloured, are greatly augmented in length, so as to overtop the florets, which are scarce larger than those of the same flower in a natural state. The florets too in the margin, which in the natural flower are female, become, by luxuriance, barren; that is, are deprived of the pistillum; the style, which was very short, spreads, and is of the length of the chaffy scales; and its summits, formerly two in number, are metamorphosed into one.

Full flowers are more easily referred to their respective genera in methods founded upon the calyx, as the flower-cup generally remains unaffected by this highest degree of luxuriance.

PLEONASM, a figure in *Rhetoric*, whereby we use words seemingly superfluous, in order to express a thought with the greater energy; such as, "I saw it with my own eyes," &c. See ORATORY, N° 67.

PLESCOW, a town of Russia, capital of a duchy of the same name, with an archbishop's see, and a strong castle. It is a large place, and divided into four parts, each of which is surrounded with walls. It is seated on the river Muldow, where it falls into the lake Plescow, 80 miles south of Narva, and 150 south by west of Petersburg. E. Long. 27. 52. N. Lat. 57. 58.

PLESCOW, a duchy in Russia, between the duchies of Novogorod, Lithuania, Livonia, and Ingria.

PLESSIS-LES-TOURS, formerly a royal palace of France, within half a league of Tours. It was built by Louis XI. and in it he died in the year 1483. It is situated in a plain surrounded by woods, at a small distance from the Loire. The building is yet handsome, though built of brick, and converted to purposes of commerce.

PLETHORA, in *Medicine*, from πληθος, "plenitude." A plethora is when the vessels are too much loaded with fluids. The plethora may be sanguine or serous. In the first there is too much crassamentum in the blood, in the latter too little. In the sanguine plethora, there is danger of a fever, inflammation, apoplexy, rupture of the blood-vessels, obstructed secretions, &c.: in the

the ſerous, of a dropſy, &c. A rarefaction of the blood produces all the effects of a plethora; it may accompany a plethora, and ſhould be diſtinguiſhed therefrom. Mr Bromfield obſerves, that a ſanguine plethora may thus be known to be preſent by the pulſe. An artery overcharged with blood is as incapable of producing a ſtrong full pulſe, as one that contains a deficient quantity; in both caſes there will be a low and weak pulſe. To diſtinguiſh rightly, the pulſe muſt not be felt with one or two fingers on the carpal artery; but if three or four fingers cover a conſiderable length of the artery, and we preſs hard for ſome time on it, and then ſuddenly raiſe all theſe fingers except that which is neareſt to the patient's hand, the influx of the blood, if there is a plethora, will be ſo rapid as to raiſe the other finger, and make us ſenſible of the fulneſs. The ſanguine plethora is relieved by bleeding: the ſerous by purging, diuretics, and ſweating. See MEDICINE *Index*.

PLEURA, in *Anatomy*, a thin membrane covering the inſide of the thorax. See ANATOMY *Index*.

PLEURITIS, or PLEURISY. See MEDICINE *Index*.

PLEURONECTES, a genus of fiſhes belonging to the order of thoracici. See ICHTHYOLOGY *Index*.

PLEURS, a town in France, which was buried under a mountain in the year 1618. Of this fatal circumſtance, Biſhop Burnet, in his Travels, p. 96. gives the following account. "Having mentioned (ſays the Biſhop) ſome falls of mountains in theſe parts (viz. near the Alps), I cannot paſs by the extraordinary fate of the town of Pleurs, about a league from Chavennes to the north.—The town was half the bigneſs of Chavennes, but much more nobly built; for, beſides the great palace of the Francken, that coſt ſome millions, there were many other palaces built by rich factors both of Milan and the other parts of Italy, who, liking the ſituation and air, as well as the freedom of the government, gave themſelves all the indulgences that a vaſt wealth could furniſh. By one of the palaces that was a little diſtant from the town, and was not overwhelmed with it, one may judge of the reſt. It was an out-houſe of the family of the Francken, and yet it may compare with many palaces in Italy. The voluptuouſneſs of this place became very crying; and Madame de Salis told me that ſhe heard her mother often relate ſome paſſages of a Proteſtant miniſter's ſermons that preached in a little church there, who warned them often of the terrible judgements of God which were hanging over their heads, and which he believed would ſuddenly break out upon them.

"On the 25th of Auguſt 1618, an inhabitant came and told me to be gone, for he ſaw the mountains cleaving; but he was laughed at for his pains. He had a daughter whom he perſuaded to leave all and go with him; but when ſhe was ſafe out of town, ſhe called to mind that ſhe had not locked the door of a room in which ſhe had ſome things of value, and ſo ſhe went back to do that, and was buried with the reſt; for at the hour of ſupper the hill fell down, and buried the town and all the inhabitants, to the number of 2200, ſo that not one perſon eſcaped. The fall of the mountains did ſo fill the channel of the river, that the firſt news thoſe of Chavennes had of it was by the failing of their river; for three or four hours there came not a drop of water, but the river wrought for itſelf a new courſe, and returned to them.

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"I could hear no particular character of the man who eſcaped (continues the Biſhop); ſo I muſt leave the ſecret reaſon of ſo ſingular a preſervation to the great diſcovery, at the laſt day, of thoſe ſteps of Divine Providence that are now ſo unaccountable. Some of the family of the Francken got ſome miners to work under ground, to find out the wealth that was buried in their houſe; for, beſides their plate and furniture, there was a great deal of caſh and many jewels in the houſe. The miners pretended they could find nothing; but they went to their country of Tyrol and built fine houſes, and a great wealth appeared, of which no other viſible account could be given but this, that they had found ſome of that treaſure."

PLEXUS, among anatomiſts, a bundle of ſmall veſſels interwoven in the form of net-work; thus a congeries of veſſels within the brain is called *plexus choroides*, *reticularis*, or *retiformis*. See ANATOMY.

A plexus of nerves is the union of two or more nerves, forming a ſort of ganglion or knot.

PLICA POLONICA, or *plaited hair*, is a diſeaſe peculiar to Poland; whence the name. See MEDICINE, N° 355. Mr Coxe, who gives a ſhort account of it, attempts likewiſe to give the phyſical cauſes of it. Many cauſes of this kind, he tells us, have been ſuppoſed to concur in rendering the plica more frequent in thoſe regions than in other parts. It would be an endleſs work to enumerate the various conjectures with which each perſon has ſupported his favourite hypotheſis.—The moſt probable are thoſe aſſigned by Dr Vicat: The firſt cauſe is the nature of the Poliſh air, which is rendered inſalubrious by numerous woods and moraſſes, and occaſionally derives an uncommon keenneſs even in the midſt of ſummer from the poſition of the Carpathian mountains; for the ſouthern and ſouth-eaſterly winds, which uſually convey warmth in other regions, are in this chilled in their paſſage over their ſnowy ſummits. The ſecond is, unwholeſome water; for although Poland is not deficient in good ſprings, yet the common people uſually drink that which is neareſt at hand, taken indiſcriminately from rivers, lakes, and even ſtagnant pools. The third cauſe is the groſs inattention of the natives to cleanlineſs; for experience ſhows, that thoſe who are not negligent in their perſons and habitations, are leſs liable to be afflicted with the plica than others who are deficient in that particular. Thus perſons of higher rank are leſs ſubject to this diſorder than thoſe of inferior ſtations; the inhabitants of large towns than thoſe of ſmall villages; the free peaſants than thoſe in an abſolute ſtate of vaſſalage; the natives of Poland Proper than thoſe of Lithuania. Whatever we may determine as to the poſſibility that all or any of theſe cauſes, by themſelves, or in conjunction with others, originally produced the diſorder; we may venture to aſſert, that they all, and particularly the laſt, aſſiſt its propagation, inflame its ſymptoms, and protract its cure.

In a word, the plica polonica appears to be a contagious diſtemper; which, like the leproſy, ſtill prevails among a people ignorant in medicine, and inattentive to check its progreſs, but is rarely known in thoſe countries where proper precautions are taken to prevent its ſpreading.

PLIMPTON, a town of Devonſhire, in England, ſeated on a branch of the river Plime, which had once a caſtle, now in ruins. It ſends two members to parliament;

ment; is seven miles E. of Plymouth, and 218 W. by S. of London. W. Long. 40. 0. N. Lat. 50. 22.

PLINIA, a genus of plants belonging to the polyandria class of Linnæus. See BOTANY *Index*.

PLINTH, ORLE, or *Orlo*, in *Architecture*, a flat square member, in the form of a brick. It is used as the foundation of columns, being that flat square table under the moulding of the base and pedestal at the bottom of the whole order. It seems to have been originally intended to keep the bottom of the original wooden pillars from rotting. Vitruvius also calls the Tuscan abacus *plinth*.

PLINTH of a Statue, &c. is a base, either flat, round, or square, that serves to support it.

PLINTH of a Wall, denotes two or three rows of bricks advancing out from a wall; or, in general, any flat high moulding, that serves in a front-wall to mark the floors, to sustain the eaves of a wall, or the larmier of a chimney.

PLINY the ELDER, or *Cæcilius Plinius Secundus*, one of the most learned men of ancient Rome, was descended from an illustrious family, and born at Verona. He bore arms in a distinguished post; was one of the college of augurs; became intendant of Spain; and was employed in several important affairs by Vespasian and Titus, who honoured him with their esteem. The eruption of Mount Vesuvius, which happened in the year 79, proved fatal to him. His nephew, Pliny the Younger, relates the circumstances of that dreadful eruption, and the death of his uncle, in a letter to Tacitus. Pliny the Elder wrote a Natural History in 37 books, which is still extant, and has had many editions; the most esteemed of which is that of Father Hardouin, printed at Paris in 1723, in two volumes folio.

PLINY the Younger, nephew of the former, was born in the ninth year of Nero, and the 62d of Christ, at Novocomum, a town upon the lake Larius, near which he had several beautiful villas. Cæcilius was the name of his father, and Plinius Secundus that of his mother's brother, who adopted him. He brought into the world with him fine parts and an elegant taste, which he did not fail to cultivate early; for, as he tells us himself, he wrote a Greek tragedy at 14 years of age. He lost his father when he was young; and had the famous Virginius for his tutor or guardian, whom he has set in a glorious light. He frequented the schools of the rhetoricians, and heard Quintilian; for whom he ever after entertained so high an esteem, that he bestowed a considerable portion upon his daughter at her marriage. He was in his 18th year when his uncle died; and it was then that he began to plead in the forum, which was the usual road to dignities. About a year after, he assumed the military character, and went into Syria with the commission of tribune: but this did not suit his taste any more than it had done Tully's; and therefore we find him returning after a campaign or two. He tells us, that in his passage homewards he was detained by contrary winds at the island Icaria, and how he employed himself in making verses: he enlarges in the same place upon his poetical exercitations; yet poetry was not the shining part of his character any more than it had been of Tully's.

Upon his return from Syria, he married a wife, and settled at Rome: it was in the reign of Domitian. During this most perilous time, he continued to plead in the forum, where he was not more distinguished by his uncommon abilities and eloquence, than by his great resolution and courage, which enabled him to speak boldly, when scarcely one else durst speak at all. On these accounts he was often singled out by the senate to defend the plundered provinces against their oppressive governors, and to manage other causes of a like important and dangerous nature. One of these was for the province of Bætica, in their prosecution of Bæbius Massa; in which he acquired so general an applause, that the emperor Nerva, then a private man, and in banishment at Tarentum, wrote to him a letter, in which he congratulated not only Pliny, but the age which had produced an example so much in the spirit of the ancients. Pliny relates this affair in a letter to Cornelius Tacitus; and he was so pleased with it himself, that he could not help intreating this friend to record it in his history. He intreats him, however, with infinitely more modesty than Tully had intreated Lucceius upon the same occasion: and though he might imitate Cicero in the request, as he professes to have constantly set that great man before him for a model, yet he took care not to transgress the bounds of decency in his manner of making it. He obtained the offices of questor and tribune, and luckily went unhurt through the reign of Domitian: there is, however, reason to suppose, if that emperor had not died just as he did, that Pliny would have shared the fate of many other great men; for he tells us himself, that his name was afterwards found in Domitian's tables, among the number of those who were destined to destruction.

He lost his wife in the beginning of Nerva's reign, and soon after married his beloved Calphurnia, of whom we read so much in his Epistles. He had not, however, any children by any of his wives: and hence we find him thanking Trajan for the *jus trium liberorum*, which he afterwards obtained of that emperor for his friend Suetonius Tranquillus. He hints also, in his letter of thanks to Trajan, than he had been twice married in the reign of Domitian. He was promoted to the consulate by Trajan in the year 100, when he was 38 years of age; and in this office pronounced that famous panegyric, which has ever since been admired, as well for the copiousness of the topics as the elegance of address. Then he was elected augur, and afterwards made proconsul of Bithynia; whence he wrote to Trajan that curious letter concerning the primitive Christians; which, with Trajan's rescript, is happily extant among his Epistles. Pliny's letter, as Mr Melmoth observes in a note upon the passage, is esteemed as almost the only genuine monument of ecclesiastical antiquity relating to the times immediately succeeding the apostles, it being written at most not above 40 years after the death of St Paul. It was preserved by the Christians themselves, as a clear and unsuspicious evidence of the purity of their doctrines, and is frequently appealed to by the early writers of the church against the calumnies of their adversaries. It is not known what became of Pliny after his return from Bithynia; whether he lived at Rome, or what time he spent at his country houses. Antiquity is also silent as to the time of his death: but it is conjectured that he died either a little before or soon after that excellent prince, his admired Trajan; that is, about the year of Christ 116.

Pliny was one of the greatest wits, and one of the worthiest

worthieſt men, among the ancients. He had fine parts, which he cultivated to the utmoſt; and he accompliſhed himſelf with all the various kinds of knowledge which could ſerve to make him either uſeful or agreeable. He wrote and publiſhed a great number of things; but nothing has eſcaped the wreck of time except the books of Letters, and the panegyric upon Trajan. This has ever been conſidered as a maſterpiece: and if he has, as ſome think, almoſt exhauſted all the ideas of perfection in a prince, and gone perhaps a little beyond the truth, yet it is allowed that no panegyriſt was ever poſſeſſed of a finer ſubject, and on which he might better indulge in all the flow of eloquence, without incurring the ſuſpicion of flattery and lies. His letters ſeem to have been intended for the public; and in them he may be conſidered as writing his own memoirs. Every epiſtle is a kind of hiſtorical ſketch, wherein we have a view of him in ſome ſtriking attitude either of active or contemplative life. In them are preſerved anecdotes of many eminent perſons, whoſe works have come down to us, as Suetonius, Silius Italicus, Martial, Tacitus, and Quintilian; and of curious things, which throw great light upon the hiſtory of thoſe times. They are written with great politeneſs and ſpirit; and if they abound too much in turn and metaphor, we muſt impute it to that degeneracy of taſte which was then accompanying the degenerate manners of Rome. Pliny, however, ſeems to have preſerved himſelf in this latter reſpect from the general contagion: whatever the manners of the Romans were, his were pure and incorrupt. His writings breathe a ſpirit of tranſcendent goodneſs and humanity: his only imperfection is, he was too deſirous that the public and poſterity ſhould know how humane and good he was. We have two elegant Engliſh tranſlations of his Epiſtles; the one by Mr Melnoth, and the other by Lord Orrery.

PLOCAMA, a genus of plants belonging to the pentandria claſs. See BOTANY *Index*,

PLOCE. See ORATORY, p. 433.

PLOCKSKO, a town of Poland, and capital of a palatinate of the ſame name, with a caſtle and a biſhop's ſee. The churches are very magnificent; and it is built upon a hill, whence there is a fine proſpect every way, near the river Viſtula. It is 25 miles ſouth-eaſt of Uladiſlaw, and 65 weſt of Warſaw. E. Long. 19. 29. N. Lat. 52. 46.

PLOCKSKO, a palatinate of Poland, bounded on the north by Regal Pruſſia, on the eaſt by the palatinate of Mazovia, on the ſouth by the Viſtula, and on the weſt by the palatinate of Inovladiſlaw. The capital town is of the ſame name.

PLOEN is a town of Germany in the circle of Lower Saxony, and capital of Holſtein. It ſtands on the banks of a lake of the ſame name, and gave title to a duke, till by the death of the laſt duke Charles without male iſſue it eſcheated to the king of Denmark in 1761. The ducal palace, riſing in the midſt of the town, on an elevated ſpot of ground, and overlooking the lake, is a very pictureſque object. The town ſtands 22 miles north-weſt of Lubeck, and 10 ſouth-eaſt of Kiell. E. Long. 10. 30. N. Lat. 54. 11.

PLOMO, in *Metallurgy*, is a name given by the Spaniards, who have the care of the ſilver mines, to the ſilver ore, when found adhering to the ſurface of ſtones, and when it incruſts their cracks and cavities like ſmall and looſe grains of gun-powder. Though theſe grains be few in number, and the reſt of the ſtone have no ſilver in it, yet they are always very happy when they find it, as it is a certain token that there is a rich vein ſomewhere in the neighbourhood. And if in digging forwards they ſtill meet with theſe grains, or the plomo in greater quantity, it is a certain ſign that they are getting nearer and nearer the good vein.

PLOT, DR ROBERT, a learned antiquarian and philoſopher, was born at Sutton-barn, in the pariſh of Borden in Kent, in the year 1641, and ſtudied in Magdalen-hall, and afterwards in Univerſity-college, Oxford. In 1682 he was elected ſecretary of the Royal Society, and publiſhed the Philoſophical Tranſactions from N° 143 to N° 166 incluſive. The next year Elias Aſhmole, Eſq. appointed him firſt keeper of his muſeum, and about the ſame time the vice-chancellor nominated him firſt profeſſor of chemiſtry in the univerſity of Oxford. In 1687 he was made ſecretary to the Earl Marſhal, and the following year received the title of *Hiſtoriographer* to King James II. In 1690 he reſigned his profeſſorſhip of chemiſtry, and likewiſe his place of keeper of the muſeum, to which he preſented a very large collection of natural curioſities; which were thoſe he had deſcribed in his hiſtories of Oxfordſhire and Staffordſhire: the former publiſhed at Oxford in 1677, folio, and reprinted with additions and corrections in 1705; and the latter was printed in the ſame ſize in 1686. In January 1694-5, Henry Howard, Earl Marſhal, nominated him Mobray-herald extraordinary; two days after which he was conſtituted regiſter of the court of honour; and, on the 30th of April 1696, he died of the ſtone at his houſe in Borden.

As Dr Plot delighted in natural hiſtory, the above works were deſigned as eſſays towards a Natural Hiſtory of England; and he had actually formed a deſign of travelling through England and Wales for that purpoſe. He accordingly drew up a plan of his ſcheme in a letter to the learned Biſhop Fell; which is inſerted at the end of the ſecond volume of Leland's Itinerary, of the edition of 1744. Amongſt ſeveral MSS. which he left behind him were large materials for the "Natural Hiſtory of Kent, Middleſex, and the city of London." Beſides the above works, he publiſhed *De origine fontium tentamen philoſophicum*, 8vo, and nine papers in the Philoſophical Tranſactions.

PLOT, in dramatic poetry, is ſometimes uſed for the fable of a tragedy or comedy; but more properly for the knot or intrigue, which makes the *embarras* of any piece. See POETRY.

PLOT, in *Surveying*, the plan or draught of any field, farm, or manor, ſurveyed with an inſtrument, and laid down in the proper figure and dimenſions.

PLOTINUS, a Platonic philoſopher in the third century. He was born at Lycopolis, a city of Egypt, in 204; and began very early to ſhow a great ſingularity both in his taſte and manners: for, at eight years of age, when he went to ſchool, he uſed to run to his nurſe, and uncover her breaſt to ſuck; and would have continued that practice longer, if he had not been diſcouraged by her. At 28 years of age he had a ſtrong deſire to ſtudy philoſophy, on which occaſion he was recommended to the moſt famous profeſſors of Alexandria. He was not ſatisfied with their lectures; but, upon

Plotinus. upon hearing those of Ammonius, he confessed that this was the man he wanted. He studied for 11 years under that excellent master, and then went to hear the Persian and Indian philosophers: for in 243, when the emperor Gordianus intended to wage war against the Persians, he followed the Roman army, but probably repented of it; for it was with difficulty he could save his life by flight, after the emperor had been slain. He was then 39; and the year following he went to Rome, and read philosophical lectures in that city; but avoided following the example of Erennius and Origen, his fellow-pupils, who, having promised with him not to reveal some hidden and excellent doctrines they had received from Ammonius, had nevertheless forfeited their word. Plotinus continued ten years in Rome, without writing any thing; but, in his 50th year, Porphyry became his scholar; who, being of an exquisitely fine genius, was not satisfied with superficial answers, but required to have all difficulties thoroughly explained; and therefore Plotinus, to treat things with greater accuracy, was obliged to write more books. He had before written 21 books, and during the six years of Porphyry's stay with him he wrote 24, and 9 after Porphyry's leaving Rome, in all 54. The Romans had a high veneration for him; and he passed for a man of such judgement and virtue, that many persons of both sexes, when they found themselves dying, intrusted him, as a kind of guardian angel, with the care of their estates and children. He was the arbiter of numberless law-suits; and constantly behaved with such humanity and rectitude of mind, that he did not create himself one enemy during the 26 years he resided in Rome. He, however, did not meet with the same justice from all of his own profession; for Olympias a philosopher of Alexandria, being envious of his glory, used his utmost endeavours, though in vain, to ruin him. The emperor Gallienus, and the empress Salonina, had a very high regard for him; and, had it not been for the opposition of some jealous courtiers, they would have had the city of Campania rebuilt, and given to him with the territory belonging to it, to establish a colony of philosophers, and to have it governed by the ideal laws of Plato's commonwealth. He laboured under various disorders during the last year of his life, which obliged him to leave Rome, when he was carried to Campania to the heirs of one of his friends, who furnished him with every thing necessary; and he died there in the year 270, at the age of 66, and in the noblest manner that an heathen philosopher could do, these being his words as he breathed his last: "I am labouring with all my might to return the divine part of me to the Divine Whole which fills the universe."

We have already remarked that the ideas of Plotinus were singular and extraordinary; and we shall now show that they were so. He was ashamed of being lodged in a body, for which reason he did not care to tell the place of his birth or family. The contempt he had for all earthly things, was the reason why he would not permit his picture to be drawn: and when his disciple Amelius was urgent with him upon this head, "Is it not enough (said he) to drag after us, whithersoever we go, that image in which nature has shut us up? Do you think that we should likewise transmit to future ages an image of that image, as a sight worthy of their attention?" From the same principle, he refused to attend to his health; for he never made use of preservatives or baths, and did not even eat the flesh of tame animals. He ate but little, and abstained very often from bread; which, joined to his intense meditation, kept him very much from sleeping. In short, he thought the body altogether below his notice; and had so little respect for it, that he considered it as a prison, from which it would be his supreme happiness to be freed. When Amelius, after his death, inquired about the state of his soul of the oracle of Apollo, he was told, "that it was gone to the assembly of the blessed, where charity, joy, and a love of the union with God prevail:" and the reason given for it, as related by Porphyry, is, "that Plotinus had been peaceable, gracious, and vigilant; that he had perpetually elevated his spotless soul to God; that he had loved God with his whole heart; that he had disengaged himself, to the utmost of his abilities, from this wretched life; that, elevating himself with all the powers of his soul, and by the several gradations taught by Plato, towards that Supreme Being which fills the universe, he had been enlightened by him; had enjoyed the vision of him without the help or interposition of ideas; had, in short, been often united to him." This is the account of Porphyry, who tells us also, that he himself had once been favoured with the vision. To this account, however, we need scarcely add, that little credit is due: it agrees pretty much with modern enthusiasm and the reveries of Behmenists. Plotinus had also his familiar spirit, as well as Socrates; but, according to Porphyry, it was not one of those called *demons*, but of the order of those who are called *gods*; so that he was under the protection of a genius superior to that of other men. The superiority of his genius puffed him up not a little: for when Amelius desired him to share in the sacrifices, which he used to offer up on solemn festivals, "It is their business (replied Plotinus) to come to me, not mine to go to them:" "which lofty answer (says Porphyry) no one could guess the reason of, or dared to ask."

Porphyry put the 54 books of Plotinus in order, and divided them into six enneases. The greater part of them turn on the most high-flown ideas in metaphysics; and this philosopher seems, in certain points, not to differ much from Spinoza. He wrote two books to prove, that "all being is one and the same;" which is the very doctrine of Spinoza. He inquires, in another book, "Whether there are many souls, or only one?" His manner of composing partook of the singularity of his nature: he never read over his compositions after he had written them; he wrote a bad hand, and was not exact in his orthography: he stood in need, therefore, of a faithful friend to revise and correct his writings; and he chose Porphyry for this purpose before Amelius, who had, however, been his disciple 24 years, and was very much esteemed by him. Some have accused Plotinus of plagiarism, with regard to Numenius; a slander which Amelius refuted. Longinus was once much prejudiced against our great philosopher, and wrote against his Treatise of Ideas, and against Porphyry's answer in defence of that treatise. He afterwards conceived a high esteem for him; sought industriously for all his books; and, in order to have them very correct, desired Porphyry to lend him his copy; but at the same time wrote to him in the following manner: "I always observed to you, when we were together,

gether, when we were at a diſtance from one another, as well as when you lived at Tyre, that I did not comprehend many of the ſubjects treated of by Plotinus; but that I was extremely fond of his manner of writing, the variety of his knowledge, and the order and diſpoſition of his queſtions, which are altogether philoſophical." "This ſingle paſſage (ſays Bayle) ſhows the exalted genius, the exquiſite diſcernment, and judicious penetration of Longinus. It cannot be denied, that moſt ſubjects which this philoſopher examines are incomprehenſible; nevertheleſs, we diſcover in his works a very elevated, fruitful, and capacious genius, and a cloſe way of reaſoning. Had Longinus been an injudicious critic, had he not poſſeſſed an exalted and beautiful genius, he would not have been ſo ſenſible of Plotinus's obſcurity: for no perſons complain leſs of the obſcurity of a book, than thoſe whoſe thoughts are confuſed and underſtanding is ſhallow." Marſilius Ficinus, at the requeſt of Coſmo de Medicis, made a Latin verſion of the works of Plotinus, with a ſummary and analyſis of each book; which was printed at Baſil, firſt by itſelf, in 1559, and afterwards with the Greek in 1580, folio. His life was written by Porphyry, the moſt illuſtrious of his diſciples.

PLOTUS, or DARTER, a genus of birds belonging to the order ANSERES. See ORNITHOLOGY *Index*.

PLOUGH, in *Agriculture*, a machine for turning up the ſoil by the action of cattle, contrived to ſave the time, labour, and expence, which, without this inſtrument, muſt have been employed in digging the ground, and fitting it for receiving all ſorts of ſeed. See AGRICULTURE.

PLOUGHMAN, the perſon who guides the plough in the operation of tilling.

PLOUGHING, in *Agriculture*, the turning up the earth with a plough. See AGRICULTURE, *paſſim*.

PLOVER, the Engliſh name of ſeveral ſpecies of CHARADRIUS, ORNITHOLOGY *Index*.

PLOWDEN, EDMUND, ſerjeant at law, deſcended from an ancient family in Shropſhire, was born in 1517, and was firſt a ſtudent of the univerſity of Cambridge, where he ſpent three years in the ſtudy of philoſophy and medicine. He then removed to Oxford, where, having continued his former ſtudies about four years more, in 1552 he was admitted to the practice of phyſic and ſurgery: but probably finding the practice of the art of healing leſs agreeable than the ſtudy, he entered himſelf of the Middle Temple, and began to read law. Wood ſays, that in 1557 he was ſummer reader to that ſociety, and Lent-reader three years after, being then ſergeant and oracle of the law. He died in the year 1584, aged 67; and was buried in the Temple church. He wrote, 1. Commentaries or Reports of divers Caſes, &c. in the reigns of King Edward VI. Queen Mary, and Queen Elizabeth; London, 1571, 78, 99, 1613, &c. Written in the old Norman language. 2. Queries, or a Moot-book of caſes, &c. tranſlated, methodized, and enlarged, by H. B. of Lincoln's-Inn. London, 1662, 8vo.

PLUCHE, ANTONY, a celebrated French writer, was born at Rheims in 1688, and having diſtinguiſhed himſelf by his engaging manners and proficiency in the belles-lettres, was appointed profeſſor of humanity in the univerſity of that city. Two years after he obtained the chair of rhetoric, and was admitted into holy orders. The biſhop of Laon (Clermont) informed of his talents, conferred upon him the direction of the college of his epiſcopal city. By his induſtry and ſuperior knowledge, a proper order and ſubordination ſoon took place in it; but ſome peculiar opinions reſpecting the affairs of the time diſturbed his tranquillity, and obliged him to quit his office. The intendant of Rouen, at the requeſt of the celebrated Rollin, entruſted him with the education of his ſon. Abbé Pluche having filled that place with ſucceſs and great honour to himſelf, left Rouen and went to Paris, where, by the patronage of ſome literary friends and his own excellent writings, he acquired a very diſtinguiſhed reputation for learning. He publiſhed, 1. *Le Spectacle de la Nature* (Nature Diſplayed), in 9 vols in 12mo. This work, which is equally inſtructive and entertaining, is written with perſpicuity and elegance; but the form of dialogue which is adopted has rendered it rather prolix. The ſpeakers, who are the Prior, the Count, and Counteſs, are not diſtinguiſhed by any ſtriking feature; but they have all the common character, which is tolerably pleaſing, not excepting even that of the little chevalier de Breuil, who is, however, a mere ſcholar. This is the opinion which Abbé Desfontaines has formed of this work. Though the author has given the converſations a pretty ingenious turn, and even ſome vivacity, yet now and then they aſſume the tone of the college. 2. *Hiſtoire du Ciel*, or Hiſtory of the Heavens, in 2 vols in 12mo. In this performance we find two parts almoſt independent of one another. The firſt contains ſome learned inquiries into the origin of the poetic heavens. It is nearly a complete mythology, founded upon ideas which are new and ingenious. The ſecond is the hiſtory of the opinions given by philoſophers reſpecting the formation of the world. The author ſhows the inutility, the inconſtancy, and uncertainty, of the moſt eſteemed ſyſtems; and concludes with pointing out the excellence and ſublime ſimplicity of the Moſaic account. Beſides a noble and well-turned expreſſion, we find in it an erudition which does not fatigue the mind. As to the foundation of the ſyſtem explained in the firſt part, though it appears extremely plauſible, we will not take upon us to ſay how far it is true: Voltaire called it *Fable du Ciel*, or a Fable of the Heavens. 3. *De Linguarum artificio*; a work which he tranſlated with this title, *La Mecanique des Langues*, in 12mo. In this treatiſe he propoſes a ſhort and eaſy method of learning languages, which is by the uſe of tranſlations inſtead of themes or exerciſes; his reflections on that ſubject are judicious and well expreſſed. 4. Harmony of the Pſalms and the Goſpel, or a Tranſlation of the Pſalms and Hymns of the Church, with Notes relative to the Vulgate, the Septuagint, and Hebrew Text, printed at Paris in 1764, in 12mo. In 1749, Abbé Pluche retired to Varenne St Maure, where he gave himſelf up entirely to devotion and ſtudy. Having become ſo deaf that he could not hear without the help of a trumpet, the capital afforded him little entertainment. It was in this retreat that he died of an apoplexy on the 20th of November 1761, at the age of 73 years. He poſſeſſed thoſe qualities which form the ſcholar, the honeſt man, and the Chriſtian: temperate in his meals, true to his word, an affectionate parent, a ſenſible friend, and a humane philoſopher; he gave leſſons of virtue in his life as well as his writings. His ſubmiſſion to all the dogmas of religion was very great.

Some Deists having been surprised that, in matters of faith, he should think and speak like the vulgar, his answer was, "I glory in doing so: It is infinitely more rational to believe the word of God, than to follow the glimmering lights of a reason which is limited and subject to error."

PLUG, certain pieces of timber, formed like the frustum of a cone, and used to stop the hause-holes and the breaches made in the body of a ship by cannon-balls; the former of which are called *hause-plugs*, and the latter *shot-plugs*, which are formed of various sizes in proportion to the holes made by the different sizes of shot, which may penetrate the ship's sides or bottom in battle; accordingly they are always ready for this purpose.

PLUKENET, Leonard, a physician who flourished in the reign of King Charles II. was one of the most excellent and laborious botanists of that or any other age. He was author of the *Phytographia Plukenetiana*, the *Almagesticum Britannicum*, and other works of the like kind, on which he spent the greatest part of his life and fortune. His Phytography is mentioned with the highest encomiums in the Philosophical Transactions for February 1696-7. His *Opera Botanica*, with cuts, were printed at London in 6 vols folio, in 1720.

PLUM-tree. See Prunus, Botany *Index*.

PLUMAGE, the feathers which serve birds for a covering. See Ornithology.

PLUMB-line, among artificers, denotes a perpendicular to the horizon; so called, as being commonly erected by means of a plummet.

PLUMBAGO, Lead-wort; a genus of plants belonging to the pentandria class. See Botany *Index*.

Plumbago, or *Black-Lead*. See Graphite, Mineralogy *Index*.

PLUMBERY, the art of casting and working lead, and using it in building.

As this metal melts soon and with little heat, it is easy to cast it into figures of any kind, by running it into moulds of brass, clay, plaster, &c. But the chief article in plumbery is sheets and pipes of lead; and as these make the basis of the plumber's work, we shall here give the process of making them.

In casting *sheet-lead*, a table or mould is made use of, which consists of large pieces of wood well jointed, and bound with bars of iron at the ends; on the sides of which runs a frame consisting of a ledge or border of wood, three inches thick and four inches high from the mould, called the *sharps*: The ordinary width of the mould, within these sharps, is from four to five feet; and its length is 16, 17, or 18 feet. This should be something longer than the sheets are intended to be, in order that the end where the metal runs off from the mould may be cut off, because it is commonly thin or uneven, or ragged at the end. It must stand very even or level in breadth, and something falling from the end in which the metal is poured in, viz. about an inch or an inch and a half in the length of 16 or 17 feet or more, according to the thickness of the sheets wanted; for the thinner the sheet, the more declivity the mould should have. At the upper end of the mould stands the pan, which is a concave triangular prism, composed of two planks nailed together at right angles, and two triangular pieces fitted in between them at the ends. The length of this pan is the whole breadth of the mould in which the sheets are cast; it stands with its bottom, which is a sharp edge, on a form at the end of the mould, leaning with one side against it; and on the opposite side is a handle to lift it up by, to pour out the melted lead; and on that side of the pan next the mould are two iron hooks to take hold of the mould, and prevent the pan from slipping while the melted lead is pouring out of it into the mould. This pan is lined on the inside with moistened sand, to prevent it from being fired by the hot metal. The mould is also spread over, about two inches thick, with sand sifted and moistened, which is rendered perfectly level by moving over it a piece of wood called a *strike*, and smoothing it over with a smoothing plane, which is a plate of polished brass, about one-fourth of an inch thick and nine inches square, turned up on all the four edges, and with a handle fitted on to the upper or concave side. The sand being thus smoothed, it is fit for casting sheets of lead; but if they would cast a cistern, they measure out the bigness of the four sides; and having taken the dimensions of the front or fore-part, make mouldings by pressing long slips of wood, which contain the same mouldings, into the level sand; and form the figures of birds, beasts, &c. by pressing in the same manner leaden figures upon it, and then taking them off, and at the same time smoothing the surface where any of the sand is raised up by making these impressions upon it. The rest of the operation is the same in casting either cisterns or plain sheets of lead. But before we proceed to mention the manner in which that is performed, it will be necessary to give a more particular description of the *strike*. The strike, then, is a piece of board about five inches broad, and something longer than the breadth of the mould on the inside; and at each end is cut a notch about two inches deep, so that when it is used it rides upon the sharps with those notches. Before they begin to cast, the strike is made ready by tacking on two pieces of an old hat on the notches, or by slipping a case of leather over each end, in order to raise the under side about one-eighth of an inch or something more above the sand, according as they would have the sheet to be in thickness; then they tallow the under edge of the strike, and lay it across the mould. The lead being melted, it is put into the pan with ladles, in which, when there is a sufficient quantity for the present purpose, the scum of the metal is swept off with a piece of board to the edge of the pan, letting it settle on the sand, which is by this means prevented from falling into the mould at the pouring out of the metal. When the lead is cool enough, which must be regulated according to the thickness of the sheets wanted, and is known by its beginning to stand with a shell or wall on the sand round the pan, two men take the pan by the handle, or else one of them lifts it by the bar and chain fixed to a beam in the ceiling, and pour it into the mould, while another man stands ready with the strike, and, as soon as they have done pouring in the metal, puts on the mould, sweeps the lead forward, and draws the overplus into a trough prepared to receive it. The sheets being thus cast, nothing remains but to roll them up or cut them into any measure wanted: but if it be a cistern, it is bent into four sides, so that the two ends may join the back, where they are soldered together; after which the bottom is soldered up.

The method of casting pipes without soldering.—To make

make these pipes they have a kind of little mill, with arms or levers to turn it withal. The moulds are of brass, and consist of two pieces, which open and shut by means of hooks and hinges, their inward caliber or diameter being according to the size of the pipe, usually two feet and a half. In the middle is placed a core or round piece of brass or iron, somewhat longer than the mould, and of the thickness of the inward diameter of the pipe. This core is passed through two copper rundles, one at each end of the mould, which they serve to close; and to these is joined a little copper tube about two inches long, and of the thickness the leaden pipe is intended to be of. By means of these tubes, the core is retained in the middle of the cavity of the mould. The core being in the mould, with the rundles at its two ends, and the lead melted in the furnace, they take it up in a ladle, and pour it into the mould by a little aperture at one end, made in the form of a funnel. When the mould is full, they pass a hook into the end of the core, and, turning the mill, draw it out; and then opening the mould, take out the pipe. If they desire to have the pipe lengthened, they put one end of it in the lower end of the mould, and pass the end of the core into it; then shut the mould again, and apply its rundle and tube as before, the pipe just cast serving for a rundle, &c. at the other end, Things being thus replaced, they pour in fresh metal, and repeat the operation till they have got a pipe of the length required.

For making pipes of sheet-lead, the plumbers have wooden cylinders, of the length and thickness required; and on these they form their pipes by wrapping the sheet around them, and soldering up the edges all along them.

The lead which lines the Chinese tea-boxes is reduced to a thinness which we are informed European plumbers cannot imitate. The following account of the process by which the plates are formed was communicated to a writer in the Gentleman's Magazine by an intelligent officer of an East Indiaman. The caster sits by a pot containing the melted metal; and has two large stones, the under one fixed, the upper moveable, directly before him. He raises the upper stone by pressing his foot upon the side of it, and with an iron ladle pours in the opening a proper quantity of the fluid metal. He then immediately lets fall the upper stone, and by that means forms the lead into a thin irregular plate, which is afterwards cut into a proper shape. The surfaces of the stones, where they touch each other, are exactly ground together.

PLUMBUM, Lead. See LEAD, CHEMISTRY *Index*.

PLUMBUM Corneum, or muriate of lead, a combination of lead with muriatic acid. See LEAD, CHEMISTRY *Index*.

PLUME, or PLUMULA, in *Botany*, the bud or germ. See GEMMA.

PLUMIER, CHARLES, a learned Minim, born at Marseilles, and one of the most able botanists of the 17th century. He was instructed by the famous Maignan, who taught him mathematics, turnery, the art of making spectacles, burning-glasses, microscopes, and other works. He at length went to Rome to perfect himself in his studies, and there applied himself entirely to botany under a skilful Italian. At his return to Provence, he settled in the convent at Bornes, a maritime place near Hieres, where he had the conveniency of making discoveries in the fields with respect to simples. He was some time after sent by the French king to America, to bring from thence such plants as might be of service in medicine. He made three different voyages to the Antilles, and visited the island of St Domingo. The king honoured him with a pension; and he at last settled at Paris. However, at the desire of M. Fagon, he prepared to go a fourth time to America, to examine the tree which produces the Jesuits bark; but died at the port of Santa Maria, near Cadiz, in 1706. He wrote several excellent works; the principal of which are. 1. A volume of the Plants in the American Islands. 2. A Treatise on the American Fern. 3. The Art of Turnery; a curious work embellished with plates.

PLUMMET, *PLUMB-Rule*, or *Plumb-line*, an instrument used by carpenters, masons, &c. in order to judge whether walls, &c. be upright planes, horizontal, or the like. It is thus called from a piece of lead, fastened to the end of a cord, which usually constitutes this instrument. Sometimes the string descends along a wooden ruler, &c. raised perpendicularly on another; in which case it becomes a level.

PLUMMING, among miners, is the method of using a mine-dial, in order to know the exact place of the work where to sink down an air-shaft, or to bring an adit to the work, or to know which way the load inclines when any flexure happens in it.

It is performed in this manner: A skilful person with an assistant, and with pen, ink, and paper, and a long line, and a mine-dial, after his guess of the place above ground, descends into the adit or work, and there fastens one end of the line to some fixed thing in it; then the incited needle is let to rest, and the exact point where it rests is marked with a pen: he then goes on farther in, the line still fastened, and at the next flexure of the adit he makes a mark on the line by a knot or otherwise: and then letting down the dial again, he there likewise notes down that point at which the needle stands in this second position. In this manner he proceeds, from turning to turning, marking down the points, and marking the line, till he comes to the intended place: this done, he ascends and begins to work on the surface of the earth what he did in the adit, bringing the first knot in the line to such a place where the mark of the place of the needle will again answer its pointing, and continues this till he come to the desired place above ground, which is certain to be perpendicular over the part of the mine into which the air-shaft is to be sunk.

PLUMOSE, something formed in the manner of a feather, with a stem and fibres issuing from it on each side; such are the antennæ of certain moths, butterflies, &c.

PLURAL, in *Grammar*, an epithet applied to that number of nouns and verbs which is used when we speak of more than one thing. See GRAMMAR.

PLURALITY, a discrete quality, consisting of two or a greater number of the same kind: thus we say, a plurality of gods, &c. See the article ASTRONOMY, N° 157. for the arguments both for and against a plurality of worlds.

PLURALITY

Plurality.

PLURALITY of Benefices, or *Livings*, is where the same clerk is possessed of two or more spiritual preferments with cure of souls. See BENEFICE.

The smallness of some benefices first gave rise to pluralities; for an ecclesiastic, unable to subsist on a single one, was allowed to hold two; and at length the number increased without bounds. A remedy was attempted for this abuse at the council of Lateran under Alexander III. and Innocent III. in the year 1215, when the holding more than one benefice was forbid by a canon under the penalty of deprivation; but the same canon granting the pope a power to dispense with it in favour of persons of distinguished merit, the prohibition became almost useless. They were also restrained by statute 21 Hen. VIII. cap. 13. which enacts, that if any person having one benefice with cure of souls, of the yearly value of 8l. or above (in the king's books), accept any other with cure of souls, the first shall be adjudged in law to be void, &c. though the same statute provides for dispensation in certain cases.

In England, in order to procure a dispensation, the presentee must obtain of the bishop, in whose diocese the livings are, two certificates of the values in the king's books, and the reputed values and distance; one for the archbishop, and the other for the lord-chancellor. And if the livings lie in two dioceses, then two certificates of the same kind are to be obtained from each bishop. He must also show the archbishop his presentation to the second living; and bring with him two testimonials from the neighbouring clergy concerning his behaviour and conversation, one for the archbishop and the other for the lord-chancellor; and he must also show the archbishop his letters of orders, and a certificate of his having taken the degree of master of arts at the least, in one of the universities of this realm, under the hand of the register. And if he be not doctor or bachelor of divinity, nor doctor nor bachelor of law, he is to procure a qualification of a chaplain, which is to be duly registered in the faculty office, in order to be tendered to the archbishop, according to the statute. And if he hath taken any of the aforesaid degrees, which the statute allows as qualifications, he is to procure a certificate thereof as already mentioned, and to show the same to the archbishop; after which his dispensation is made out at the faculty office, where he gives security according to the direction of the canon. He must then repair to the lord-chancellor for confirmation under the broad seal; and he must apply to the bishop of the diocese where the living lies for his admission and institution. By the several stamp acts, for every skin, or paper, or parchment, &c. on which any dispensation to hold two ecclesiastical dignities or benefices, or a dignity and a benefice, shall be engrossed or written, there shall be paid a treble 40s. stamp duty.

We have also a regulation in regard to pluralities; but it is often dispensed with: for, by the faculty of dispensation, a pluralist is required, in that benefice from which he shall happen to be most absent, to preach 13 sermons every year, and to exercise hospitality for two months yearly.

In Germany the pope grants dispensation for possessing a plurality of benefices, on pretence that the ecclesiastical princes there need large revenues to bear up against the Protestant princes.

Plus || Plutarch.

PLUS, in *Algebra*, a character marked thus +, used for the sign of addition. See ALGEBRA.

PLUSH, in commerce, &c. a kind of stuff, having a sort of velvet knap or shag on one side, composed regularly of a woof of a single woollen thread and a double warp; the one wool, of two threads twisted; the other goats or camels hair; though there are some plushes entirely of worsted, and others composed wholly of hair.

PLUTARCH, a great philosopher and historian of antiquity, who lived from the reign of Claudius to that of Hadrian, was born at Chæronea, a small city of Bœotia in Greece. Plutarch's family was ancient in Chæronea: his grandfather Lamprias was eminent for his learning and a philosopher; and is often mentioned by Plutarch in his writings, as is also his father. Plutarch was initiated early in study, to which he was naturally inclined; and was placed under the care of Ammonius, an Egyptian, who, having taught philosophy with great reputation at Alexandria, from thence travelled into Greece, and settled at Athens. Under this master he made great advances in knowledge; and like a thorough philosopher, more apt to regard things than words, he pursued this knowledge to the neglect of languages. The Roman language at that time was not only the language of Rome, but of Greece also: and much more used there than the French is now in England. Yet he was so far from regarding it then, that, as we learn from himself, he became not conversant in it till the declension of his life: and, though he is supposed to have resided in Rome near 40 years at different times, yet he never seems to have acquired a competent skill in it. But this was not the worst: he did not cultivate his mother-tongue with any great exactness; and hence that harshness, inequality and obscurity in his style, which has so frequently and so justly been complained of.

After he was principled and grounded by Ammonius, having an insatiable thirst for knowledge, he resolved to travel. Egypt was at that time, as formerly it had been, famous for learning; and probably the mysteriousness of their doctrine might tempt him, as it had tempted Pythagoras and others, to go and converse with the priesthood of that country. This appears to have been particularly his business, by his treatise *Of Isis and Osiris*: in which he shows himself versed in the ancient theology and philosophy of the wise men. From Egypt he returned into Greece; and visiting in his way all the academies and schools of the philosophers, gathered from them many of those observations with which he has abundantly enriched posterity. He does not seem to have been attached to any particular sect, but culled from each of them whatever he thought excellent and worthy to be regarded. He could not bear the paradoxes of the Stoics, but yet was more averse from the impiety of the Epicureans: in many things he followed Aristotle; but his favourites were Socrates and Plato, whose memory he revered so highly, that he annually celebrated their birth-days with much solemnity. Besides this, he applied himself with extreme diligence to collect not only all books that were excellent in their kind, but also all the sayings and observations of wise men which he had heard in conversation or had received from others by tradition; and likewise to con-

Plutarch.

ſult the records and public inſtruments preſerved in cities which he had viſited in his travels. He took a particular journey to Sparta, to ſearch the archives of that famous commonwealth, to underſtand thoroughly the model of their ancient government, the hiſtory of their legiſlators, their kings, and their ephori; and digeſted all their memorable deeds and ſayings with much care. He took the ſame methods with regard to many other commonwealths; and thus was enabled to leave us in his works ſuch a rich cabinet of obſervation upon men and manners, as, in the opinion of Montaigne and Bayle, have rendered him the moſt valuable author of antiquity.

The circumſtances of Plutarch's life are not known, and therefore cannot be related, with any exactneſs. According to the learned Fabricius, he was born under Claudius, 50 years after the Chriſtian era. He was married to a moſt amiable woman of his own native town, whoſe name, according to the probable conjecture of Rualdus, was Timoxena, and to whoſe ſenſe and virtue he has borne the moſt affectionate teſtimony in his moral works. He had ſeveral children, and among them two ſons; one called *Plutarch* after himſelf, the other *Lamprias* in memory of his grandfather. Lamprias was he, of all his children, who ſeems to have inherited his father's philoſophy; and to him we owe the table or catalogue of Plutarch's writings, and perhaps alſo his apophthegms. He had a nephew, Sextus Chæroneus, who taught the learned emperor Marcus Aurelius the Greek tongue, and was much honoured by him. Some think, that the critic Longinus was of his family; and Apuleius, in the firſt book of his Metamorphoſes, affirms himſelf to be deſcended from him.

On what occaſion, and at what time of his life, he went to Rome, how long he lived there, and when he finally returned to his own country, are all uncertain. It is probable, that the fame of him went thither before him, not only becauſe he had publiſhed ſeveral of his works, but becauſe immediately upon his arrival, as there is reaſon to believe, he had a great reſort of the Roman nobility to hear him: for he tells us himſelf, that he was ſo taken up in giving lectures of philoſophy to the great men of Rome, that he had not time to make himſelf maſter of the Latin tongue, which is one of the firſt things that would naturally have engaged his attention. It appears that he was ſeveral times at Rome; and perhaps one motive for his living there was the intimacy he had contracted in ſome of theſe journeys with Soſſius Senecio, a great and worthy man, who had been four times conſul, and to whom Plutarch has dedicated many of his lives. But the great inducement which carried him firſt to Rome, was undoubtedly that which had carried him into ſo many other parts of the world; namely, to make obſervations upon men and manners, and to collect materials for writing the lives of the Roman worthies, in the ſame manner as he had already written thoſe of the Grecian: and accordingly he not only converſed with all the living, but ſearched the records of the Capitol, and of all the libraries. Not but, as we learn from Suidas, he was intruſted alſo with the management of public affairs in the empire, during his reſidence in the metropolis. "Plutarch (ſays he) lived in the time of Trajan, who beſtowed on him the conſular ornaments, and alſo cauſed an edict to be paſſed, that the magiſtrates or officers of Illyria ſhould do nothing in that province without his knowledge and approbation."

Plutarch, Pluto.

When and how he was made known to Trajan is likewiſe uncertain: but it is generally ſuppoſed that Trajan, a private man when Plutarch firſt came to Rome, was, among other nobility, one of his auditors. It is alſo ſuppoſed, that this wiſe emperor made uſe of him in his councils; at leaſt, much of the happineſs of his reign has been imputed to Plutarch. Fabricius aſſerts that he was Trajan's preceptor, and that he was raiſed to the conſular dignity by him, and made procurator of Greece in his old age by the emperor Adrian. We are equally at a loſs concerning the time of his abode in the imperial city; which, however, at different times, is not imagined to fall much ſhort of 40 years. The deſire of viſiting his native country, ſo natural to all men, and eſpecially when growing old, prevailed with him at length to leave Italy: and at his return he was unanimouſly choſen archon or chief magiſtrate of Chæronea, and not long after admitted into the number of the Delphic Apollo's prieſts. We have no particular account of his death, either as to the manner of it or the year; only it is evident that he lived, and continued his ſtudies, to a good old age. The moſt probable conjecture is that of Fabricius, who ſays he died in the fifth year of Adrian, at the age of 70.

His works have been divided, and they admit of a pretty equal diviſion, into Lives and Morals: the former of which, in his own eſtimation, were to be preferred as more noble than the latter. His ſtyle, as we have already obſerved, has been excepted to with ſome reaſon: he has alſo been criticiſed for ſome miſtakes in Roman antiquities, and for a little partiality to the Greeks. On the other hand, he has been juſtly praiſed for the copiouſneſs of his fine ſenſe and learning, for his integrity, and for a certain air of goodneſs which appears in all he wrote. His buſineſs was not to pleaſe the ear, but to inſtruct and charm the mind; and in this none ever went beyond him. Of his moral writings it is to be regretted that we have no elegant Engliſh tranſlation. Even his Lives were chiefly known to the Engliſh reader by a motley and miſerable verſion, till a new one executed with fidelity and ſpirit was preſented to the public by the Langhornes in 1770. On the whole, it is to be wiſhed that this moſt amiable moraliſt and biographer had added a life of himſelf to thoſe which he has given to the world of others, as the particulars which other writers have preſerved of his perſonal hiſtory are very doubtful and imperfect.

PLUTO, in Pagan worſhip, the king of the infernal regions, was the ſon of Saturn and Ops, and the brother of Jupiter and Neptune. This deity finding himſelf childleſs and unmarried, mounted his chariot to viſit the world; and arriving in Sicily, fell in love with Proſerpine, whom he ſaw gathering flowers with her companions in the valley of Enna, near Mount Ætna: when, forcing her into his chariot, he drove her to the river Chemarus, through which he opened himſelf a paſſage back to the realms of night. See CERES and PROSERPINE.

Pluto is uſually repreſented in an ebony chariot drawn by four black horſes; ſometimes holding a ſceptre, to denote his power; at others, a wand, with which he drives away the ghoſts; and at others, ſome keys, to ſignify that he had the keys of death. Homer obſerves, that

that his helmet had the quality of rendering the wearer invisible, and that Minerva borrowed it in order to be concealed from Mars when she fought against the Trojans. Pluto was greatly revered both by the Greeks and Romans, who erected temples and altars to him. To this god sacrifices were offered in the night, and it was not lawful to offer them by day.

PLUTUS, in Pagan worship, the god of riches, is frequently confounded with Pluto. He was represented as appearing lame when he approached, and with wings at his departure; to show the difficulty of amassing wealth, and the uncertainty of its enjoyment. He was also frequently represented blind, to show that he often bestowed his favours on the most unworthy, and left in necessity those who had the greatest merit.

PLUVIALIS, a species of plover. See CHARADRIUS, ORNITHOLOGY *Index*.

PLUVIUS, a surname of Jupiter. He was invoked by that name among the Romans whenever the earth was parched up by continual heat, and was in want of refreshing rains. He had an altar in the temple on the capitol.

PLYERS, in fortification, denote a kind of balance used in raising or letting down a draw-bridge. They consist of two timber levers, twice as long as the bridge they lift, joined together by other timbers framed in the form of a St Andrew's cross to counterpoise them. They are supported by two upright jambs, on which they swing; and the bridge is raised or let down by means of chains joining the ends of the plyers and bridge.

PLYING, in the sea language, the act of making, or endeavouring to make, a progress against the direction of the wind. Hence a ship that advances well in her course in this manner of sailing, is said to be a good plyer. See the articles BEATING, PITCHING, and TACKING.

PLYMOUTH, a town of Devonshire, in England, about 215 miles from London, stands between the rivers Plym and Tamar, just before they fall into the British channel. From a mere fishing village it has become one of the largest towns in the county; and is one of the chief magazines in the kingdom, on account of its port, which is one of the safest in England, and which is so large as to be able to contain 1000 sail. It is defended by several different forts, mounting altogether nearly 300 guns; of which the chief is the Royal Citadel, erected in the reign of Charles II. opposite to St Nicholas island, which is within the circuit of its walls, and contains a large store-house and five regular bastions. In time of war the outward-bound convoys generally rendezvous at Plymouth, and homeward-bound ships generally put in to provide pilots up the Channel. It is also a great place of resort for men of war that are wind-bound.

The mouth of the Tamar is called Ham-Ooze, and that of Plym Catwater, which are both commanded by the castle on St Nicholas island. About two miles up the mouth of the Tamar there are four docks, two of which were built in the reign of William III. one wet and the other dry, and two which have been built since. They have every conveniency for building or repairing ships. One of the docks is hewn out of a mine of slate, and lined with Portland stone. This town enjoys a pilchard fishery of considerable importance, and carries on an extensive trade with Newfoundland and the Straits. There is a customhouse in it; and though there are two churches (and besides several meeting-houses), yet each church has so large a cure of souls, that the parish clerks were till very lately in deacons orders, to enable them to perform all the occasional and other offices. The seat-rents are given to the poor. The lecturers are chosen every three years by the corporation, which was constituted by Henry VI. and consists of a mayor, 12 aldermen, and 24 common-council men. The mayor is elected by a jury of 36 persons, chosen by four others, two of whom are appointed by the mayor and aldermen, and the other two by the common-council. There is also a recorder, and a town-clerk, whose place is very profitable. The town consists of four divisions, which were anciently governed by four captains, each of whom had three constables under him. It is well supplied with fresh water, which was brought from the distance of seven miles, by Sir Francis Drake a native of the town. The toll of the markets, and of the cotton, yarn, &c. with the profit of the mill, which is very considerable, belongs to the corporation, as do the revenues of the shambles, which are farmed out for the mayor's kitchen. There is a charity-school in Plymouth, four hospitals, and a workhouse, in all which 100 poor children are clothed, fed, and taught; and there are two printing-houses. To one of the hospitals Colonel Jory gave a charity for 12 poor widows, as he did a mace worth 120l. to be carried before the mayor, and six good bells, valued at 500l. to Charles-Church, so called from our kings in whose reigns it was begun and finished. In the entrance of the bay lies the famous Eddystone rock, which is covered at high water, and on which the ingenious Mr Winstanley built a light-house, that was blown down in the terrible hurricane of Nov. 27th 1703, and himself, with others that were with him in it, never more heard of. However, another was erected in the room of it, by the corporation of the Trinity-house, in the time of Queen Anne, which was destroyed by an accidental fire Dec. 4th 1755, but rebuilt in 1759: which also was burnt down, and rebuilt by the celebrated Smeaton in the year 1770. In the reign of Edward III. the French landed, and burnt part of the town, but were soon repulsed by Hugh Courtenay earl of Devon. In the reign of Henry IV. the French landed here again, and burnt 600 houses. Between this town and the sea is a hill called the Haw, which has a delightful plain on the top, having a pleasant prospect all round it, and a good landmark for the use of mariners. The list of parliament-men for this borough, formerly divided into two parts, by the names of Sutton-Valtort and Sutton-Prior, commences the 26th of Edward I. and continues to the 14th of Edward III. after which we find no return made for it till the 20th of Henry VI. when the privilege was renewed. On the Haw is a fort, which at once commands the town and defends the harbour. Here is a ferry over the Tamar, called Crumwell or Crimble Passage, the west side of which is called Westone-House, and is in Devonshire, though most of the parish wherein it stands is in Cornwall. In April 1759 parliament granted 25,159l. for the better fortifying the town and dock of Plymouth. N. Lat. 50. 26. W. Long. 4. 15.

PLYMOUTH, in New England, a sea-port town, and capital of the county of the same name, in the province of

Plymouth, Plynteria.

of Maffachufets Bay, in North America. It is remarkable for having been the firft fettlement in New England, and for having had the firft place of worfhip. It is feated at the fouth end of Plymouth bay. W. Long. 70. 10. N. Lat. 41. 58.

PLYNTERIA, a Grecian feftival in honour of Aglauros, or rather of Minerva, who received from the daughter of Cecrops the name of Aglauros. The word is derived from πλυνειν, *lavare*, becaufe during the folemnity they undreffed the ftatue of the goddefs and wafhed it. The day on which it was obferved was looked upon as unfortunate and inaufpicious; and therefore no perfon was permitted to appear in the temples, as they were purpofely furrounded with ropes. The arrival of Alcibiades in Athens that day was thought very unfortunate, but the fuccefs that ever after attended him proved it to be otherwife. It was cuftomary at this feftival to bear in proceffion a clufter of figs; which intimated the progrefs of civilization among the firft inhabitants of the earth, as figs ferved them for food after they had found a diflike for acorns.

Plynteria.

PNEUMATICS.

1 Definition of the term.

THIS term is reftricted, in the prefent habits of our language, to that part of natural philofophy which treats of the mechanical properties of elaftic fluids. The word, in its original meaning, expreffes a quality of air, or more properly of breath. Under the article PHYSICS we obferved, that in a great number of languages the term ufed to exprefs breath was alfo one of the terms ufed to exprefs the animating principle, nay, the intellectual fubftance, the foul. It has been perhaps owing to fome attention to this chance of confufion that our philofophers have appropriated the term PNEUMATICS to the fcience of the mechanical properties of air, and PNEUMATOLOGY to the fcience of the intellectual phenomena confequent on the operations or affections of our thinking principle.

2 Extent of the fcience.

We have extended (on the authority of prefent cuftom) the term PNEUMATICS to the ftudy of the mechanical properties of all elaftic or fenfibly compreffible fluids, that is, of fluids whofe elafticity and compreffibility become an interefting object of our attention; as the term HYDROSTATICS is applied to the ftudy of the mechanical properties of fuch bodies as intereft us by their fluidity or liquidity only, or whofe elafticity and compreffibility are not familiar or interefting, though not lefs real or general than in the cafe of air and all vapours.

3 No precife limit to the different claffes of bodies.

We may be indulged in the obfervation by the bye, that there is no precife limit to the different claffes of natural bodies with refpect to their mechanical properties. There is no fuch thing as a body perfectly hard, perfectly foft, perfectly elaftic, or perfectly incompreffible. All bodies have fome degree of elafticity intermixed with fome degree of ductility. Water, mercury, oil, are compreffible; but their compreffibility need not be attended to in order perfectly to underftand the phenomena confequent on their materiality, fluidity, and gravity. But if we neglect the compreffibility of air, we remain ignorant of the caufe and nature of its moft interefting phenomena, and are but imperfectly informed with refpect to thofe in which its elafticity has no fhare; and it is convenient to attend to this diftinction in our refearches, in order to underftand thofe phenomena which depend folely or chiefly on compreffibility and elafticity. This obfervation is important; for here elafticity appears in its moft fimple form, unaccompanied with any other mechanical affection of matter (if we except gravity), and lies moft open to our obfervation, whether employed for inveftigating the nature of this very property of bodies, or for explaining its mode of action. We fhall even find that the conftitution of an avowedly elaftic fluid, whofe compreffibility is fo very fenfible, will give us the diftincteft notions of fluidity in general, and enable us to underftand its *characteriftic appearances*, by which it is diftinguifhed from folidity, namely, the *equable* diftribution of preffure through all its parts in every direction, and the horizontality which its furface affumes by the action of gravity: phenomena which have been affumed as equivalent to the definition of a perfect fluid, and from which all the laws of hydroftatics and hydraulics have been derived. And thefe laws have been applied to the explanation of the phenomena around us; and water, mercury, oil, &c. have been denominated fluid only becaufe their appearances have been found to tally exactly with thefe confequences of this definition, while the definition itfelf remains in the form of an affumption, unfupported by any other proof of its obtaining in nature. A real mechanical philofopher will therefore attach himfelf with great eagernefs to this property, and confider it as an introduction to much natural fcience.

4 Air the moft familiar compreffible fluid.

Of all the fenfible compreffible fluids air is the moft familiar, was the firft ftudied, and the moft minutely examined. It has therefore been generally taken as the example of their mechanical properties, while thofe mechanical properties which are peculiar to any of them, and therefore characteriftic, have ufually been treated as an appendix to the general fcience of pneumatics. No objection occurs to us againft this method, which will therefore be adopted in treating this article.

5 Different properties of it.

But although the mechanical properties are the proper fubjects of our confideration, it will be impoffible to avoid confidering occafionally properties which are more of a chemical nature; becaufe they occafion fuch modifications of the mechanical properties as would frequently be unintelligible without confidering them in conjunction with the other; and, on the other hand, the mechanical properties produce fuch modifications of the properties merely chemical, and of very interefting phenomena confequent on them, that thefe would often pafs unexplained unlefs we give an account of them in this place.

6 Mechanical properties.

By *mechanical properties* we would be underftood to mean fuch as produce, or are connected with, fenfible changes of motion, and which indicate the prefence and agency of moving or mechanical powers. They are therefore the fubject of mathematical difcuffion; admitting

ting of meaſure, number, and direction, notions purely mathematical.

We ſhall therefore begin with the conſideration of air.

7 What is air? It is by no means an idle queſtion, " *What is this* air of which ſo much is ſaid and written?" We ſee nothing, we feel nothing. We find ourſelves at liberty to move about in any direction without any let or hinderance. Whence, then, the aſſertion, that we are ſurrounded with a *matter* called air? A few very ſimple obſervations and experiments will ſhow us that this aſſertion is well founded.

8 Proofs that it is matter, Plate ccccxxiii. Fig. 1. We are accuſtomed to ſay, that a veſſel is empty when we have poured out of it the water which it contained. Take a cylindrical glaſs jar (fig. 1.), having a ſmall hole in its bottom; and having ſtopped this hole, fill the jar with water, and then pour out the water, leaving the glaſs empty, in the common acceptation of the word. Now, throw a bit of cork, or any light body, on the ſurface of water in a ciſtern: cover this with the glaſs jar A held in the hand with its bottom upwards, and move it downwards, as at B, keeping it all the while in an upright poſition. The cork will continue to float on the ſurface of the water in the inſide of the glaſs, and will moſt diſtinctly ſhow whereabouts that ſurface is. It will thus be ſeen, that the water within the glaſs has its ſurface conſiderably lower at C than that of the ſurrounding water; and however deep we immerge the glaſs, we ſhall find that the water will never riſe in the inſide of it ſo as to fill it. If plunged to the depth of 32 feet, the water will only half fill it; and yet the acknowledged laws of hydroſtatics tell us, that the water would fill the glaſs if there were nothing to hinder it. There is therefore ſomething already within the glaſs which prevents the water from getting into it; manifeſting in this manner the moſt diſtinctive property of matter, viz. the hindering other matter from occupying the ſame place at the ſame time.

9 Poſſeſſed of impulſive force, While things are in this condition, pull the ſtopper D out of the hole in the bottom of the jar, and the water will inſtantly riſe in the inſide of the jar, and ſtand at an equal height within and without. This is juſtly aſcribed to the eſcape through the hole of the *matter* which formerly obſtructed the entry of the water; for if the hand be held before the hole, a puff will be diſtinctly felt, or a feather held there will be blown aſide; indicating in this manner that what prevented the entry of the water, and now eſcapes, poſſeſſes another characteriſtic property of matter, *impulſive force*. The materiality is concluded from this appearance, in the ſame manner that the materiality of water is concluded from the impulſe of a jet from a pipe. We alſo ſee the mobility of the formerly pent up, and now liberated, ſubſtance, in conſequence of external preſſure, viz. the preſſure of the ſurrounding water.

10 Impenetrability, Alſo, if we take a ſmooth cylindrical tube, ſhut at one end, and fit a plug or cork to its open end, ſo as to ſlide along it, but ſo tightly as to prevent all paſſage by its ſides; and if the plug be well ſoaked in greaſe, we ſhall find that no force whatever can puſh it to the bottom of the tube. There is therefore *ſomething* within the tube preventing by its impenetrability the entry of the plug, and therefore poſſeſſing this characteriſtic of matter.

11 Elaſticity, In like manner, if, after having opened a pair of common bellows, we ſhut up the nozzle and valve hole, and try to bring the boards together, we find it impoſſible. There is ſomething included which prevents this, in the ſame manner as if the bellows were filled with wool; but on opening the nozzle we can eaſily ſhut them, viz. by expelling this ſomething; and if the compreſſion be forcible, the ſomething will iſſue with conſiderable force, and very ſenſibly impel any thing in its way.

It is not accurate to ſay, that we move about without *any* obſtruction: for we find, that if we endeavour to move a large fan with rapidity, a very ſenſible hinderance is perceived, and that a very ſenſible force muſt be exerted; and a ſenſible wind is produced, which will agitate the neighbouring bodies. It is therefore juſtly concluded that the motion is poſſible only in conſequence of having driven this obſtructing ſubſtance out of the way; and that this impenetrable, reſiſting, moveable, impelling ſubſtance, is *matter*. We perceive the perſeverance of this matter in its ſtate of reſt when we wave a fan, in the ſame manner that we perceive the *inertia* of water when we move a paddle through it. The effects of wind in impelling our ſhips and mills, in tearing up trees, and overturning buildings, are equal indications of its perſeverance in a ſtate of motion. 12 Inertia, and mobility.

To this matter, when at reſt, we give the name Air; and when it is in motion we call it Wind.

Air, therefore, is a material fluid: a fluid, becauſe its parts are eaſily moved, and yield to the ſmalleſt inequality of preſſure. 13 It is therefore a material fluid.

Air poſſeſſes ſome others of the very general, though not eſſential, properties of matter. It is heavy. This appears from the following facts. 14 Heavy, and

1. It always accompanies this globe in its orbit round the ſun, ſurrounding it to a certain diſtance, under the name of the Atmosphere, which indicates the being connected with the earth by its general force of gravity. It is chiefly in conſequence of this that it is continually moving round the earth from eaſt to weſt; forming what is called the trade-wind, to be more particularly conſidered afterwards. All that is to be obſerved on this ſubject at preſent is, that, in conſequence of the diſturbing force of the ſun and moon, there is an accumulation of the air of the atmoſphere, in the ſame manner as of the waters of the ocean, in thoſe parts of the globe which have the moon near their zenith or nadir: and as this happens ſucceſſively, going from the eaſt to the weſt (by the rotation of the earth round its axis in the oppoſite direction), the accumulated air muſt gradually flow along to form the elevation. This is chiefly to be obſerved in the torrid zone; and the generality and regularity of this motion are greatly diſturbed by the changes which are continually taking place in different parts of the atmoſphere from cauſes which are not mechanical.

2. It is in like manner owing to the gravity of the air that it ſupports the clouds and vapours which we ſee conſtantly floating in it. We have even ſeen bodies of no inconſiderable weight float, and even riſe, in the air. Soap bubbles, and balloons filled with inflammable gas, riſe and float in the ſame manner as a cork riſes in water. This phenomenon proves the weight of the air, in the ſame manner that the ſwimming of a piece of wood indicates the weight of the water which ſupports it. 15 ſupports the clouds.

3. But we are not left to theſe refined obſervations for 16 Familiar proofs of its weight.

for the proof of the air's gravity. We may observe familiar phenomena, which would be immediate consequences of the supposition that air is a heavy fluid, and, like other heavy fluids, presses on the outsides of all bodies immersed in or surrounded by it. Thus, for instance, if we shut the nozzle and valve hole of a pair of bellows after having squeezed the air out of them, we shall find that a very great force, even some hundred pounds, is necessary for separating the boards. They are kept together by the pressure of the heavy air which surrounds them in the same manner as if they were immersed in water. In like manner, if we stop the end of a syringe after its piston has been pressed down to the bottom, and then attempt to draw up the piston, we shall find a considerable force necessary. viz. about 15 or 16 pounds for every square inch of the section of the syringe. Exerting this force, we can draw up the piston to the top, and we can hold it there; but the moment we cease acting, the piston rushes down and strikes the bottom. It is called a suction, as we feel something as it were drawing in the piston; but it is really the weight of the incumbent air pressing it in. And this obtains in every position of the syringe; because the air is a fluid, and presses in every direction. Nay, it presses on the syringe as well as on the piston; and if the piston be hung by its ring on a nail, the syringe requires force to draw it down (just as much as to draw the piston up); Plate CCCCXXIII. Fig. 2. and if it be let go, it will spring up, unless loaded with at least 15 pounds for every square inch of its transverse section (see fig. 2.).

17 It may even be weighed.

4. But the most direct proof of the weight of the air is had by weighing a vessel empty of air, and then weighing it again when the air has been admitted; and this, as it is the most obvious consequence of its weight, has been asserted as long ago as the days of Aristotle. He says (Περὶ Ουρανου, iv. 4.), That all bodies are heavy in their place except fire; even air is heavy; for a blown bladder is heavier than when it is empty. It is somewhat surprising that his followers should have gone into the opposite opinion, while professing to maintain the doctrine of their leader. If we take a very large and limber bladder, and squeeze out the air very carefully, and weigh it, and then fill it till the wrinkles just begin to disappear, and weigh it again, we shall find no difference in the weight. But this is not Aristotle's meaning; because the bladder, considered as a vessel, is equally full in both cases, its dimensions being changed. We cannot take the air out of a bladder without its immediately collapsing. But what would be true of a bladder would be equally true of any vessel. Fig. 3. Therefore, take a round vessel A (fig. 3.), fitted with a stopcock B, and syringe C. Fill the whole with water, and press the piston to the bottom of the syringe. Then keeping the cock open, and holding the vessel upright, with the syringe undermost, draw down the piston. The water will follow it by its weight, and leave part of the vessel empty. Now shut the cock, and again push up the piston to the bottom of the syringe; the water escapes through the piston valve, as will be explained afterward: then opening the cock, and again drawing down the piston, more water will come out of the vessel. Repeat this operation till all the water have come out. Shut the cock, unscrew the syringe, and weigh the vessel very accurately. Now open the cock, and admit the air, and weigh the vessel again, it will be found heavier than before, and this additional weight is the weight of the air which fills it; and it will be found to be 523 grains, about an ounce and a fifth avoirdupois, for every cubic foot that the vessel contains. Now since a cubic foot of water would weigh 1000 ounces, this experiment would show that water is about 840 times heavier than air. The most accurate judgement of this kind of which we have met with an account is that recorded by Sir George Shuckburgh, which is in the 67th vol. of the Philosophical Transactions, p. 560. From this it follows, that when the air is of the temperature 53, and the barometer stands at 29¼ inches, the air is 836 times lighter than water. But the experiment is not susceptible of sufficient accuracy for determining the exact weight of a cubic foot of air. Its weight is very small; and the vessel must be strong and heavy, so as to overload any balance that is sufficiently nice for the experiment.

18 The most convenient method of doing this.

To avoid this inconvenience, the whole may be weighed in water, first loading the vessel so as to make it preponderate an ounce or two in the water. By this means the balance will be loaded only with this small preponderancy. But even in this case there are considerable sources of error, arising from changes in the specific gravity of the water and other causes. The experiment has often been repeated with this view, and the air has been found at a medium to be about 840 times as light as water, but with great variations, as may be expected from its very heterogeneous nature, in consequence of its being the menstruum of almost every fluid, of all vapours, and even of most solid bodies; all which it holds in solution, forming a fluid perfectly transparent, and of very different density according to its composition. It is found, for instance, that perfectly pure air of the temperature of our ordinary summer is considerably denser than when it has dissolved about half as much water as it can hold in that temperature; and that with this quantity of water the difference of density increases in proportion as the mass grows warmer, for damp air is more expansible by heat than dry air. We have had occasion to consider this subject when treating of the connection of the mechanical properties of air with the state of the weather. See METEOROLOGY.

19 This property of air denied by the Peripatetics, though acknowledged by their master.

Such is the result of the experiment suggested by Aristotle, evidently proving the weight of the air; and yet, as has been observed, the Peripatetics, who profess to follow the *dictates* of Aristotle, uniformly refused it this property. It was a matter long debated among the philosophers of the last century. The reason was, that Aristotle, with that indistinctness and inconsistency, which is observed in all his writings which relate to matters of fact and experience, assigns a different cause to many phenomena which any man led by common observation would ascribe to the weight of the air. Of this kind is the rise of water in pumps and syphons, which all the Peripatetics had for ages ascribed to something which they called *nature's abhorrence of a void.* Aristotle had asserted (for reasons not our business to adduce at present), that all nature was full of being, and that nature abhorred a void. He adduces many facts, in which it appears, that if not absolutely impossible, it is very difficult, and requires great force, to produce a space void of matter. When the operation of pumps and syphons came to be known, the philosophers of Europe: (who had all embraced the Peripatetic

doctrines)

doctrines) found in this fancied horror of a fancied mind (what else is this that nature abhors?) a ready solution of the phenomena. We shall state the facts, that every reader may see what kinds of reasoning were received among the learned not two centuries ago.

20 Construction of pumps in the last century. Fig. 4.

Pumps were then constructed in the following manner: A long pipe GB (fig. 4.) was set in the water of the well A. This was fitted with a sucker or piston C, having a long rod CF, and was furnished with a valve B at the bottom, and a lateral pipe DE at the place of delivery, also furnished with a valve. The fact is, that if the piston be thrust down to the bottom, and then drawn up, the water will follow it; and upon the piston being again pushed down, the water shuts the valve B by its weight, and escapes or is expelled at the valve E; and on drawing up the piston again the valve E is shut, the water again rises after the piston, and is again expelled at its next descent.

21 Their operation accounted for by the Peripatetics.

The Peripatetics explain all this by saying, that if the water did *not follow the piston* there would be a void between them. But nature abhors a void; or a void is impossible: therefore the water follows the piston.— It is not worth while to criticise the wretched reasoning in this pretence to explanation. It is all overturned by one observation. Suppose the pipe shut at the bottom, the piston *can* be drawn up, and thus a void produced. No, say the Peripatetics; and they speak of certain spirits, effluvia, &c. which occupy the place. But if so, why needs the water rise? This therefore is not the cause of its ascent. It is a curious and important phenomenon.

22 Galileo first accounted for it rationally

The sagacious Galileo seems to have been the first who seriously ascribed this to the weight of the air. Many before him had supposed air heavy; and thus explained the difficulty of raising the board of bellows, or the piston of a syringe, &c. But he distinctly applies to this allowed weight of the air all the consequences of hydrostatical laws; and he reasons as follows.

23 by the weight of the atmosphere,

The heavy air rests on the water in the cistern, and presses it with its weight. It does the same with the water in the pipe, and therefore both are on a level: but if the piston, after being in contact with the surface of the water, be drawn up, there is no longer any pressure on the surface of the water within the pipe; for the air now rests on the piston only, and thus occasions a difficulty in drawing it up. The water in the pipe, therefore, is in the same situation as if more water were poured into the cistern, that is, as much as would exert the same pressure on its surface as the air does. In this case we are certain that the water will be pressed into the pipe, and will raise up the water already in it, and follow it till it is equally high within and without. The same pressure of the air shuts the valve E during the descent of the piston. (See *Gal. Discourses*).

24 and predicted the height to which water would rise in them.

He did not wait for the very obvious objection, that if the rise of the water was the effect of the air's pressure, it would also be its measure, and would be raised and supported only to a certain height. He directly said so, and adduced this as a decisive experiment. If the horror of a void be the cause, says he, the water must rise to any height however great; but if it be owing to the pressure of the air, it will only rise till the weight of the water in the pipe is in equilibrio with the pressure of the air, according to the common laws of hydrostatics. And he adds, that this is well known; for it is a fact, that pumps will not *draw* water much above forty palms, although they may be made to *propel* it, or to *lift it* to any height. He then makes an assertion, which, if true, will be decisive. Let a very long pipe, shut at one end, be filled with water, and let it be erected perpendicularly with the close end uppermost, and a stopper in the other end, and then its lower orifice immersed into a vessel of water; the water will subside in the pipe upon removing the stopper, till the remaining column is in equilibrio with the pressure of the external air. This experiment he proposes to the curious; saying, however, that he thought it unnecessary, their being already such abundant proofs of the air's pressure.

25 His prediction verified by Toricelli's experiment.

It is probable that the cumbersomeness of the necessary apparatus protracted the making of this experiment. Another equally conclusive, and much easier, was made in 1642 after Galileo's death, by his zealous and learned disciple Toricelli. He filled a glass tube, close at one end, with mercury; judging, that if the support of the water was owing to the pressure of the air, and was the measure of this pressure, mercury would in like manner be supported by it, and this at a height which was also the measure of the air's pressure, and therefore 13 times less than water. He had the pleasure of seeing his expectation verified in the completest manner; the mercury descending in the tube AB (fig. 5.), and finally settling at the height fB of $29\frac{3}{4}$ Roman inches: and he found, that when the tube was inclined, the point f was in the same horizontal plane with f in the upright tube, according to the received laws of hydrostatical pressure. The experiment was often repeated, and soon became famous, exciting great controversies among the philosophers about the possibility of a vacuum. About three years afterwards the same experiment was published, at Warsaw in Poland, by Valerianus Magnus, as his own suggestion and discovery: but it appears plain from the letters of Roberval, not only that Toricelli was prior, and that his experiment was the general topic of discussion among the curious; but also highly probable that Valerianus Magnus was informed of it when at Rome, and daily conversant with those who had seen it. He denies, however, even having heard of the name of Toricelli. Fig. 5.

26 Origin of the Royal Society, &c.

This was the era of philosophical ardour; and we think that it was Galileo's invention and immediate application of the telescope which gave it vigour. Discoveries of the most wonderful kind in the heavens, and which required no extent of previous knowledge to understand them, were thus put into the hands of every person who could purchase a spy-glass; while the high degree of credibility which some of the discoveries, such as the phases of Venus and the rotation and satellites of Jupiter, gave to the Copernican system, immediately set the whole body of the learned in motion. Galileo joined to his ardour a great extent of learning, particularly of mathematical knowledge and sound logic, and was even the first who formally united mathematics with physics; and his treatise on accelerated motion was the first, and a precious fruit of this union. About the years 1642 and 1644, we find clubs of gentlemen associated in Oxford and London for the cultivation of knowledge by experiment; and before 1655 all the doctrines of hydrostatics and pneumatics were familiar there, established upon experiment. Mr Boyle procured a coalition and correspondence of these clubs under the name of the Invisible and Philosophical Society. In May 1658 Mr Hooke finished for Mr Boyle

27 Invention of the air-pump.

Boyle an air-pump, which had employed him a long time, and occasioned him several journeys to London for things which the workmen of Oxford could not execute. He speaks of this as a great improvement on Mr Boyle's own pump, which he had been using some time before. Boyle therefore must have invented his air-pump, and was not indebted for it to Schottus's account of Otto Guerick's, published in his (Schottus) *Mechanica Hydraulo-pneumatica* in 1657, as he asserts (*Techna Curiosa*). The Royal Society of London arose in 1656 from the coalition of these clubs, after 15 years co-operation and correspondence. The Montmorine Society at Paris had subsisted nearly about the same time; for we find Paschal in 1648 speaking of the meetings in the Sorbonne College, from which we know that society originated.— Nuremberg, in Germany, was also a distinguished seminary of experimental philosophy. The magistrates, sensible of its valuable influence in many manufactures, the source of the opulence and prosperity of their city, and many of them philosophers, gave philosophy a professed and munificent patronage, furnishing the philosophers with a copious apparatus, a place of assembly, and a fund for the expence of their experiments; so that this was the first academy of sciences out of Italy under the patronage of government. In Italy, indeed, there had long existed institutions of this kind. Rome was the centre of church-government, and the resort of all expectants for preferment. The clergy was the majority of the learned in all Christian nations, and particularly of the systematic philosophers. Each, eager to recommend himself to notice, brought forward every thing that was curious; and they were the willing vehicles of philosophical communication. Thus the experiments of Galileo and Toricelli were rapidly diffused by persons of rank, the dignitaries of the church, or by the monks their obsequious servants. Perhaps the recent defection of England, and the want of a residing embassy at Rome, made her sometimes late in receiving or spreading philosophical researches, and was the cause that more was done there *proprio Marte*.

28 The experiments of Galileo and Toricelli rapidly diffused.

We hope to be excused for this digression, We were naturally led into it by the pretensions of Valerianus Magnus to originality in the experiment of the mercury supported by the pressure of the air. Such is the strength of national attachment, that there were not wanting some who found that Toricelli had borrowed his experiment from Honoratus Fabri, who had proposed and explained it in 1641; but whoever knows the writings of Toricelli, and Galileo's high opinion of him, will never think that he could need such helps. (See this surmise of Mounier in *Schott. Tech. Cur.* III. at the end).

29 The merit of Toricelli's claimed by others

Galileo must be considered as the author of the experiment when he proposes it to be made. Valerianus Magnus owns himself indebted to him for the principle and the contrivance of the experiment. It is neither wonderful that many ingenious men, of one opinion, and instructed by Galileo, should separately hit on so obvious a thing; nor that Toricelli, his immediate disciple, his enthusiastic admirer, and who was in the habits of corresponding with him till his death in 1642, should be the first to put it in practice. It became the subject of dispute from the national arrogance and self-conceit of some Frenchmen, who have always shown themselves disposed to consider their nation as at the head of the republic of letters, and cannot brook the concurrence of any foreigners. Roberval was in this instance, however, the champion of Toricelli; but those who know his controversies with the mathematicians of France at this time will easily account for this exception.

All now agree in giving Toricelli the honour of the *first* invention; and it universally passes by the name of the Toricellian Experiment. The tube is called the Toricellian Tube; and the space left by the mercury is called the Toricellian Vacuum, to distinguish it from the Boylean Vacuum, which is only an extreme rarefaction.

30 unjustly.

31 It was repeated in various forms.

The experiment was repeated in various forms, and with apparatus which enabled philosophers to examine several effects which the vacuum produced on bodies exposed in it. This was done by making the upper part of the tube terminate in a vessel of some capacity, or communicate with such a vessel, in which were included along with the mercury bodies on which the experiments were to be made. When the mercury had run out, the phenomena of these bodies were carefully observed.

32 An objection to the conclusion drawn from it obviated.

An objection was made to the conclusion drawn from Toricelli's experiment, which appears formidable. If the Toricellian tube be suspended on the arm of a balance, it is found that the counterpoise must be equal to the weight both of the tube and of the mercury it contains. This could not be, say the objectors, if the mercury were supported by the air. It is evidently supported by the balance; and this gave rise to another notion of the cause different from the peripatetic *fuga vacui*: a suspensive force, or rather attraction, was assigned to the upper part of the tube.

But the true explanation of the phenomenon is most easy and satisfactory. Suppose the mercury in the cistern and tube to freeze, but without adhering to the tube, so that the tube could be freely drawn up and down. In this case the mercury is supported by the base, without any dependence on the pressure of the air; and the tube is in the same condition as before, and the solid mercury performs the office of a piston to this kind of syringe. Suppose the tube thrust down till the top of it touches the top of the mercury. It is evident that it must be drawn up in opposition to the pressure of the external air, and it is precisely similar to the syringe mentioned in N° 16. The weight sustained therefore by this arm of the balance is the weight of the tube and the downward pressure of the atmosphere on its top.

33 Galileo's original experiment performed.

The curiosity of philosophers being thus excited by this very manageable experiment, it was natural now to try the original experiment proposed by Galileo. Accordingly Berti in Italy, Paschal in France, and many others in different places, made the experiment with a tube filled with water, wine, oil, &c. and all with the success which might be expected in so simple a matter: and hence the doctrine of the weight and pressure of the air was established beyond contradiction or doubt. All this was done before the year 1648.—A very beautiful experiment was exhibited by Auzout, which completely satisfied all who had any remaining doubts.

34 An experiment by Auzout

Fig. 6.

A small box or phial EFGH (fig. 6.) had two glass tubes, AB, CD, three feet long, inserted into it in such a manner as to be firmly fixed in one end, and to reach nearly to the other end. AB was open at both ends, and CD was close at D. This apparatus was completely filled with mercury, by unscrewing the tube AB, filling

ling the box, and the tube CD; then ſcrewing in the tube AB, and filling it: then holding a finger on the orifice A, the whole was inverted and ſet upright in the poſition repreſented in figure *β*, immerſing the orifice A (now *a* of fig. *β*.) in a ſmall veſſel of quickſilver. The reſult was, that the mercury ran out at the orifice *a*, till its ſurface *m n* within the phial deſcended to the top of the tube *b a*. The mercury alſo began to deſcend in the tube *d c* formerly DC) and run over into the tube *b a*, and run out at *a*, till the mercury in *d c* was very near equal in a level with *m n*. The mercury deſcending in *b a* till it ſtood at *k*, $29\frac{1}{2}$ inches above the ſurface *o p* of the mercury in the ciſtern, juſt as in the Toricellian tube.

The rationale of this experiment is very eaſy. The whole apparatus may firſt be conſidered as a Toricellian tube of an uncommon ſhape, and the mercury would flow out at *a*. But as ſoon as a drop of mercury comes out, leaving a ſpace above *m n*, there is nothing to keep up the mercury in the tube *d c*. Its mercury therefore deſcends alſo; and running over into *b a*, continues to ſupply its expence till the tube *d c* is almoſt empty, or can no longer ſupply the waſte of *b a*. The inner ſurface therefore falls as low as it can, till it is level with *b*. No more mercury can enter *b a*, yet its column is too heavy to be ſupported by the preſſure of the air on the mercury in the ciſtern below; it therefore deſcends in *b a*, and finally ſettles at the height *h o*, equal to that of the mercury in the Toricellian tube.

35
decisive of the queſtion.

The pretticſt circumſtance of the experiment remains. Make a ſmall hole *g* in the upper cap of the box. The external air immediately ruſhes in by its weight, and now preſſes on the mercury in the box. This immediately raiſes the mercury in the tube *d c* to *l*, $29\frac{1}{2}$ inches above *m n*. It preſſes on the mercury at *k* in the tube *b a*, balancing the preſſure of the air in the ciſtern. The mercury in the tube therefore is left to the influence of its own weight, and it deſcends to the bottom. Nothing can be more appoſite or deciſive.

36
The gravity of the air therefore a ſtatical principle from which we obtain

And thus the doctrine of the gravity and preſſure of the air is eſtabliſhed by the moſt unexceptionable evidence: and we are intitled to aſſume it as a ſtatical principle, and to affirm *à priori* all its legitimate conſequences.

37
an exact meaſure of the preſſure of the atmoſphere.

And in the firſt place, we obtain an exact meaſure of the preſſure of the atmoſphere. It is preciſely equal to the weight of the column of mercury, of water, of oil, &c. which it can ſupport; and the Toricellian tube, or others fitted up upon the ſame principle, are juſtly termed *baroſcopes* and *barometers* with reſpect to the air. Now it is obſerved that water is ſupported at the height of 32 feet nearly: The weight of the column is exactly 2000 avoirdupois pounds on every ſquare foot of baſe, or $13\frac{9}{10}$ on every ſquare inch. The ſame concluſion very nearly may be drawn from the column of mercury, which is nearly $29\frac{1}{2}$ inches high when in equilibrium with the preſſure of the air. We may here obſerve, that the meaſure taken from the height of a column of water, wine, ſpirits, and the other fluids of conſiderable volatility, as chemiſts term it, is not ſo exact as that taken from mercury, oil, and the like. For it is obſerved, that the volatile fluids are converted by the ordinary heat of our climates into vapour when the confining preſſure of the air is removed; and this vapour, by its elaſticity, exerts a ſmall preſſure on the ſurface of the water, &c. in the pipe, and thus counteracts a ſmall part of the external preſſure; and therefore the column ſupported by the remaining preſſure muſt be lighter, that is, ſhorter. Thus it is found, that rectified ſpirits will not ſtand much higher than is competent to a weight of 13 pounds on an inch, the elaſticity of its vapour balancing about $\frac{1}{15}$ of the preſſure of the air. We ſhall afterwards have occaſion to conſider this matter more particularly.

As the medium height of the mercury in the barometer is $29\frac{1}{2}$ inches, we ſee that the whole globe ſuſtains a preſſure equal to the whole weight of a body of mercury of this height; and that all bodies on its ſurface ſuſtain a part of this in proportion to their ſurfaces. An ordinary ſized man ſuſtains a preſſure of ſeveral thouſand pounds. How comes it then that we are not ſenſible of a preſſure which one ſhould think enough to cruſh us together? This has been conſidered as a ſtrong objection to the preſſure of the air; for when a man is plunged a few feet under water, he is very ſenſible of the preſſure. 38
A difficulty ſolved.

The anſwer is by no means ſo eaſy as is commonly imagined. We feel very diſtinctly the effects of removing this preſſure from any part of the body. If any one will apply the open end of a ſyringe to his hand, and then draw up the piſton, he will find his hand ſucked into the ſyringe with great force, and it will give pain; and the ſoft part of the hand will ſwell into it, being preſſed in by the neighbouring parts, which are ſubject to the action of the external air. If one lays his hand on the top of a long perpendicular pipe, ſuch as a pump filled to the brim with water, which is at firſt prevented from running out by the valve below; and if the valve be then opened, ſo that the water deſcends, he will then find his hand ſo hard preſſed to the top of the pipe that he cannot draw it away. But why do we only feel the *inequality* of preſſure? There is a ſimilar inſtance wherein we do not feel it, although we cannot doubt of its exiſtence. When a man goes ſlowly to a great depth under water in a diving-bell, we know unqueſtionably that he is expoſed to a new and very great preſſure, yet he does not feel it. But thoſe facts are not ſufficiently familiar for general argument. The human body is a bundle of ſolids, hard or ſoft, filled or mixed with fluids, and there are few or no parts of it which are empty. All communicate either by veſſels or pores; and the whole ſurface is a ſieve through which the inſenſible perſpiration is performed. The whole extended ſurface of the lungs is open to the preſſure of the atmoſphere; every thing is therefore in equilibrio: and if free or ſpeedy acceſs be given to every part, the body will not be damaged by the preſſure, however great, any more than a wet ſponge would be deranged by plunging it any depth in water. The preſſure is inſtantaneouſly diffuſed by means of the incompreſſible fluids with which the parts are filled; and if any parts are filled with air or other compreſſible fluids, theſe are compreſſed till their elaſticity again balances the preſſure. Beſides, all our fluids are acquired ſlowly, and gradually mixed with that proportion of air which they can diſſolve or contain. The whole animal has grown up in this manner from the firſt vital atom of the embryo. For ſuch reaſons the preſſure can occaſion no change of ſhape by ſqueezing together the flexible parts; nor any obſtruction by compreſſing the veſſels or pores. We cannot ſay what would be felt by a man, were it poſſible that he could have been produced

duced and grown up *in vacuo*, and then ſubjected to the compreſſion. We even know that any ſudden and conſiderable change of general preſſure is very ſeverely felt. Perſons in a diving-bell have been almoſt killed by letting them down or drawing them up too ſuddenly. In drawing up, the elaſtic matters within have ſuddenly ſwelled, and not finding an immediate eſcape have burſt the veſſels. Dr Halley experienced this, the blood guſhing out from his ears by the expanſion of air contained in the internal cavities of this organ, from which there are but very ſlender paſſages.

39 The weather-glaſs. A very important obſervation recurs here: the preſſure of the atmoſphere is variable. This was obſerved almoſt as ſoon as philoſophers began to attend to the barometer. Paſchal obſerved it in France, and Deſcartes obſerved it in Sweden in 1650. Mr Boyle and others obſerved it in England in 1656. And before this, obſervers, who took notice of the concomitancy of theſe changes of aerial preſſure with the ſtate of the atmoſphere, remarked, that it was generally greateſt in winter and in the night; and certainly moſt variable during winter and in the northern regions. Familiar now with the weight of the air, and conſidering it as the vehicle of the clouds and vapours, they noted with care the connection between the weather and the preſſure of the air, and found that a great preſſure of the air was generally accompanied with fair weather, and a diminution of it with rain and miſts. Hence the barometer came to be conſidered as an index not only of the preſent ſtate of the air's weight, but alſo as indicating by its variations changes of weather. It became a WEATHER-GLASS, and continued to be anxiouſly obſerved with this view. This is an important ſubject, and in another place is treated in ſome detail.

40 The preſſure of the air in proportion to the elevation. In the next place, we may conclude that the preſſure of the air will be different in different places, according to their elevation above the ſurface of the ocean: for if air be an heavy fluid, it muſt preſs in ſome proportion according to its perpendicular height. If it be a homogeneous fluid of equal denſity and weight in all its parts, the mercury in the ciſtern of a barometer muſt be preſſed preciſely in proportion to the depth to which that ciſtern is immerſed in it; and as this preſſure is exactly meaſured by the height of the mercury in the tube, the height of the mercury in the Toricellian tube muſt be exactly proportional to the depth of the place of obſervation under the ſurface of the atmoſphere.

41 firſt ſuppoſed by Deſcartes and Paſchal, and proved by experiments, The celebrated Deſcartes firſt entertained this thought (Epiſt. 67. of Pr. III.), and ſoon after him Paſchal. His occupation in Paris not permitting him to try the juſtneſs of his conjecture, he requeſted Mr Perrier a gentleman of Clermont in Auvergne, to make the experiment, by obſerving the height of the mercury at one and the ſame time at Clermont and on the top of a very high mountain in the neighbourhood. His letters to Mr Perrier in 1647 are ſtill extant. Accordingly Mr Perrier, in September 1648, filled two equal tubes with mercury, and obſerved the heights of both to be the ſame, viz. $26\frac{7}{24}$ inches, in the garden of the convent of the Friars Minims, ſituated in the loweſt part of Clermont. Leaving one of them there, and one of the fathers to obſerve it, he took the other to the top of Puy de Domme, which was elevated nearly 500 French fathoms above the garden. He found its height to be $23\frac{2}{24}$ inches. On his return to the town, in a place called *Font de l'Arbre*, 150 fathoms above the garden, he found it 25 inches; when he returned to the garden it was again $26\frac{7}{24}$, and the perſon ſet to watch the tube which had been left ſaid that it had not varied the whole day. Thus a difference of elevation of 3000 French feet had occaſioned a depreſſion of $3\frac{1}{8}$ inches; from which it may be concluded, that $3\frac{1}{8}$ inches of mercury weighs as much as 3000 feet of air, and one-tenth of an inch of mercury as much as 96 feet of air. The next day he found, that taking the tube to the top of a ſteeple 120 feet high made a fall of one-ſixth of an inch. This gives 72 feet of air for one-tenth of an inch of mercury; but ill agreeing with the former experiment. But it is to be obſerved, that a very ſmall error of obſervation of the barometer would correſpond to a great difference of elevation, and alſo that the height of the mountain had not been meaſured with any preciſion. This has been ſince done (Mem. Acad. par. 1703), and found to be 529 French toiſes.

42 which were repeated by others. Paſchal publiſhed an account of this great experiment (*Grande Exp. ſur la Peſanteur de l'Air*), and it was quickly repeated in many places of the world. In 1653 it was repeated in England by Dr Power (Power's Exper. Phil.); and in Scotland, in 1661, by Mr Sinclair profeſſor of philoſophy in the univerſity of Glaſgow, who obſerved the barometer at Lanark, on the top of Mount Tinto in Clydſdale, and on the top of Arthur's Seat at Edinburgh. He found a depreſſion of two inches between Glaſgow and the top of Tinto, three quarters of an inch between the bottom and top of Arthur's Seat, and $\frac{5}{12}$ of an inch at the cathedral of Glaſgow on a height of 126 feet. See Sinclair's *Ars Nova et Magna Gravitatis et Levitatis; Sturmii Collegium Experimentale*, and *Schotti Technica Curioſa*.

43 Hence a method of meaſuring heights. Hence we may derive a method of meaſuring the heights of mountains. Having aſcertained with great preciſion the elevation correſponding to a fall of one-tenth of an inch of mercury, which is nearly 90 feet, we have only to obſerve the length of the mercurial column at the top and bottom of the mountain, and to allow 90 feet for every tenth of an inch. Accordingly this method has been practiſed with great ſucceſs: but it requires an attention to many things not yet conſidered; ſuch as the change of denſity of the mercury by heat and cold; the changes of denſity of air, which are much more remarkable from the ſame cauſes; and above all, the changes of the denſity of air from its compreſſibility; a change immediately connected with or dependent on the very elevation we wiſh to meaſure. Of all theſe afterwards.

44 Alſo a meaſure of the denſity of the air. Theſe obſervations give us the moſt accurate meaſure of the denſity of air and its ſpecific gravity. This is but vaguely though directly meaſured by weighing air in a bladder or veſſel. The weight of a manageable quantity is ſo ſmall, that a balance ſufficiently tickliſh to indicate even very ſenſible fractions of it is overloaded by the weight of the veſſel which contains it, and ceaſes to be exact: and when we take Bernouilli's ingenious method of ſuſpending it in water, we expoſe ourſelves to great riſk of error by the variation of the water's denſity. Alſo it muſt neceſſarily be humid air which we can examine in this way: but the proportion of an elevation in the atmoſphere to the depreſſion of the column of mercury or other fluid, by which we meaſure its preſſure, gives us at once the proportion of this weight

weight or their ſpecific gravity. Thus ſince it is found that in ſuch a ſtate of preſſure the barometer ſtands at 30 inches, and the thermometer at 32°, 87 feet of riſe produces one-tenth of an inch of fall in the barometer, the air and the mercury being both of the freezing temperature, we muſt conclude that mercury is 10,440 times heavier or denſer than air. Then, by comparing mercury and water, we get $\frac{1}{801}$ nearly for the denſity of air relative to water: but this varies ſo much by heat and moiſture, that it is uſeleſs to retain any thing more than a general notion of it; nor is it eaſy to determine whether this method or that by actual weighing be preferable. It is extremely difficult to obſerve the height of the mercury in the barometer nearer than $\frac{1}{200}$ of an inch; and this will produce a difference of even five feet, or $\frac{1}{18}$ of the whole. Perhaps this is a greater proportion than the error in weighing.

45 and ſome knowledge of the height of the atmoſphere.

From the ſame experiments we alſo derive ſome knowledge of the height of the aerial covering which ſurrounds our globe. When we raiſe our barometer 87 feet above the ſurface of the ſea, the mercury falls about one-tenth of an inch in the barometer: therefore if the barometer ſhows 30 inches at the ſea-ſhore, we may expect that, by raiſing it 300 times 87 feet or 5 miles, the mercury in the tube will deſcend to the level of the ciſtern, and that this is the height of our atmoſphere. But other appearances lead us to ſuppoſe a much greater height. Meteors are ſeen with us much higher than this, and which yet give undoubted indication of being ſupported by our air. There can be little doubt, too, that the viſibility of the expanſe above us is owing to the reflection of the ſun's light by our air. Were the heavenly ſpaces perfectly tranſparent, we ſhould no more ſee them than the pureſt water through which we ſee other objects; and we ſee *them* as we ſee water tinged with milk or other fæculæ. Now it is eaſy to ſhow, that the light which gives us what is called twilight muſt be reflected from the height of at leaſt 50 miles; for we have it when the ſun is depreſſed 18 degrees below our horizon.

46 Why this knowledge is not accurate.

A little attention to the conſtitution of our air will convince us, that the atmoſphere muſt extend to a much greater height than 300 times 87 feet. We ſee from the moſt familiar facts that it is compreſſible; we can ſqueeze it in an ox-bladder. It is alſo heavy; preſſing on the air in this bladder with a very great force, not leſs than 1500 pounds. We muſt therefore conſider it as in a ſtate of compreſſion, exiſting in ſmaller room than it would aſſume if it were not compreſſed by the incumbent air. It muſt therefore be in a condition ſomething reſembling that of a quantity of fine carded wool thrown looſely into a deep pit; the lower ſtrata carrying the weight of the upper ſtrata, and being compreſſed by them; and ſo much the more compreſſed as they are further down, and only the upper ſtratum in its unconſtrained and moſt expanded ſtate. If we ſhall ſuppoſe this wool thrown in by a hundred weight at a time, it will be divided into ſtrata of equal weights, but of unequal thickneſs; the loweſt being the thinneſt, and the ſuperior ſtrata gradually increaſing in thickneſs. Now, ſuppoſe the pit filled with air, and reaching to the top of the atmoſphere, the *weights* of all the ſtrata above any horizontal plane in it is meaſured by the height of the mercury in the Toricellian tube placed in that plane; and one-tenth of an inch of mercury is juſt equal to the weight of the loweſt ſtratum 87 feet thick: for on raiſing the tube 87 feet from the ſea, the ſurface of the mercury will deſcend one-tenth of an inch. Raiſe the tube till the mercury fall another tenth: This ſtratum muſt be more than 87 feet thick; how much more we cannot tell, being ignorant of the law of the air's expanſion. In order to make it fall a third tenth, we muſt raiſe it through a ſtratum ſtill thicker; and ſo on continually.

All this is abundantly confirmed by the very firſt experiment made by the order and directions of Paſchal: For by carrying the tube from the garden of the convent to a place 150 fathoms higher, the mercury fell $1\frac{7}{24}$ inches, or 1.2916; which gives about 69 feet 8 inches of aerial ſtratum for $\frac{1}{10}$ of an inch of mercury; and by carrying it from thence to a place 350 fathoms higher, the mercury fell $1\frac{22}{24}$, or 1.9167 inches, which gives 109 feet 7 inches for $\frac{1}{10}$ of an inch of mercury. Theſe experiments were not accurately made; for at that time the philoſophers, though zealous, were but *ſcholars* in the *ſcience* of experimenting, and novices in the art. But the reſults abundantly ſhow this general truth, and they are completely confirmed by thouſands of ſubſequent obſervations. It is evident from the whole tenor of them, that the ſtrata of air decreaſe in denſity as we aſcend through the atmoſphere; but it remained to be diſcovered what is the force of this decreaſe, that is, the law of the air's expanſion. Till this be done we can ſay nothing about the conſtitution of our atmoſphere: we cannot tell in what manner it is fitteſt for raiſing and ſupporting the exhalations and vapours which are continually ariſing from the inhabited regions; not as an excrementitious waſte, but to be ſupported, perhaps manufactured, in that vaſt laboratory of nature, and to be returned to us in beneficent ſhowers. We cannot uſe our knowledge for the curious, and frequently uſeful, purpoſe of meaſuring the heights of mountains and taking the levels of extenſive regions; in ſhort, without an accurate knowledge of this, we can hardly acquire any acquaintance with thoſe mechanical properties which diſtinguiſh air from thoſe liquids which circulate here below.

Having therefore conſidered at ſome length the leading conſequences of the air's fluidity and gravity, let us conſider its compreſſibility with the ſame care; and then, combining the agency of both, we ſhall anſwer all the purpoſes of philoſophy, diſcover the laws, explain the phenomena of nature, and improve art. We proceed therefore to conſider a little the phenomena which indicate and characteriſe this other property of the air. All fluids are elaſtic and compreſſible as well as air; but in them the compreſſibility makes no figure, or does not intereſt us while we are conſidering their preſſures, motions, and impulſions. But in air the compreſſibility and expanſion draw our chief attention, and make it a proper repreſentative of this claſs of fluids. 47 Compreſſibility of the air.

Nothing is more familiar than the compreſſibility of air. It is ſeen in a bladder filled with it, which we can forcibly ſqueeze into leſs room; it is ſeen in a ſyringe, of which we can puſh the plug farther and farther as we increaſe the preſſure. 48 A familiar phenomenon, which

But theſe appearances bring into view another, and the moſt intereſting, property of air, viz. its *elaſticity*. When we have ſqueezed the air in the bladder or ſyringe into leſs room, we find that the force with which we *compreſſed* it is neceſſary to *keep it in this bulk*; and that 49 ſhews its elaſticity, that if we ceafe to prefs it together, it will fwell out and regain its natural dimenfions. This diftinguifhes it effentially from fuch a body as a mafs of flour, falt, or fuch like, which remain in the compreffed ftate to which we reduce them.

50 refifting force, and producing motion.

There is fomething therefore which oppofes the compreffion different from the fimple impenetrability of the air: there is fomething that oppofes mechanical force: there is fomething too which produces motion, not only refifting compreffion, but pufhing back the compreffing body, and communicating motion to it. As an arrow is gradually accelerated by the bow-ftring preffing it forward, and at the moment of its difcharge is brought to a ftate of rapid motion; fo the ball from a pop-gun or wind-gun is gradually accelerated along the barrel by the preffure of the air during its expanfion from its compreffed ftate, and finally quits it with an accumulated velocity. Thefe two motions are indications perfectly fimilar of the elafticity of the bow and of the air.

51 Fluidity of the air.

Thus it appears that air is heavy and elaftic. It needs little confideration to convince us in a vague manner that it is fluid. The eafe with which it is penetrated, and driven about in every direction, and the motion of it in pipes and channels, however crooked and intricate, entitle it to this character. But before we can proceed to deduce confequences from its fluidity, and to offer them as a true account of what will happen in thefe circumftances, it is neceffary to exhibit fome diftinct and fimple cafe, in which the characteriftic mechanical property of a fluid is clearly and unequivocally obferved in it. That property of fluids from which all the laws of hydroftatics and hydraulics are derived with ftricteft evidence is, that any preffure applied to any part of them is propagated through the whole mafs in every direction; and that in confequence of this diffufion of preffure, any two external forces can be put in equilibrio by the interpofition of a fluid, in the fame way as they can be put in equilibrio by the intervention of any mechanical engine.

52 experimentally Fig. 7.

Let a clofe veffel ABC (fig. 7.), of any form, have two upright pipes EDC, GFB, inferted into any parts of its top, fides, or bottom, and let water be poured into them, fo as to ftand in equilibrio with the horizontal furfaces at E, D, G, F, and let D *d*, F *f*, be horizontal lines, *it will be found* that the height of the column E *d* is fenfibly equal to that of the column G *f*. This is a fact univerfally obferved in whatever way the pipes are inferted.

53 proved.

Now the furface of the water at D is undoubtedly preffed upwards with a force equal to a column of water, having its furface for its bafe, and E *d* for its height; it is therefore prevented from rifing by fome oppofite force. This can be nothing but the elafticity of the confined air preffing it down. The very fame thing muft be faid of the furface at F; and thus there are two external preffures at D and F fet in equilibrio by the interpofition of air. The force exerted on the furface D, by the preffure of the column E *d*, is therefore propagated to the furface at F; and thus air has this characteriftic mark of fluidity.

In this experiment the *weight* of the air is infenfible when the veffel is of fmall fize, and has no fenfible fhare in the preffure reaching at D and F. But if the elevation of the point F above D is very great, the column E *d will be obferved* fenfibly to exceed the column G *f*. Thus if F be 70 feet higher than D, E *d* will be an inch longer than the column G *f*: for in this cafe there is reacting at D, not only the preffure propagated from F, but alfo the weight of a column of air, having the furface at D for its bafe and 70 feet high. This is equal to the weight of a column of water one inch high.

It is by this propagation of preffure, this *fluidity*, that the pellet is difcharged from a child's pop-gun. It fticks faft in the muzzle; and he forces in another pellet at the other end, which he preffes forward with the rammer, condenfing the air between them, and thus propagating to the other pellet the preffure which he exerts, till the friction is overcome, and the pellet is difcharged by the air expanding and following it.

There is a pretty philofophical plaything which illuftrates this property of air in a very perfpicuous manner, and which we fhall afterwards have occafion to confider as converted into a moft ufeful hydraulic machine. This is what is ufually called *Hero's fountain*, having 54 Hero's fountain. Fig. 8.
been invented by a Syracufan of that name. It confifts of two veffels KLMN (fig. 8.), OPQR, which are clofe on all fides. The tube AB, having a funnel a-top, paffes through the uppermoft veffel without communicating with it, being foldered into its top and bottom. It alfo paffes through the top of the under-veffel, where it is alfo foldered, and reaches almoft to its bottom. This tube is open at both ends. There is another open tube ST, which is foldered into the top of the under veffel and the bottom of the upper veffel, and reaches almoft to its top. Thefe two tubes ferve alfo to fupport the upper veffel. A third tube GF is foldered into the top of the upper veffel, and reaches almoft to its bottom. This tube is open at both ends, but the orifice G is very fmall. Now fuppofe the uppermoft veffel filled with water to the height EN, E *e* being its furface a little below T. Stop the orifice G with the finger, and pour in water at A. This will defcend through AB, and comprefs the air in OPQR into lefs room. Suppofe the water in the under veffel to have acquired the furface C*c*, the air which formerly occupied the whole of the fpaces OPQR, and KL*e*E will now be contained in the fpaces *o* P *c* C and KL *e* E; and its elafticity will be in equilibrio with the weight of the column of water, whofe bafe is the furface E *e*, and whofe height is A *c*. As this preffure is exerted in every part of the air, it will be exerted on the furface E *e* of the water of the upper veffel; and if the pipe FG were continued upwards, the water would be fupported in it to an height *e* H above E *e*, equal to A *c*. Therefore if the finger be now taken from off the orifice G, the water will fpout up to the fame height as if it had been immediately forced out by a column of water A *c* without the intervention of the air, that is, nearly to H. If inftead of the funnel at A, the veffel have a brim VW which will caufe the water difcharged at G to run down the pipe AB, this fountain will play till all the water in the upper veffel is expended. The operation of this fecond fountain will be better underftood from fig. 9. which an intelligent reader will fee is perfectly equivalent to fig. 8. A very powerful engine for Fig. 9.
raifing water upon this principle has long been employed in the Hungarian mines; where the pipe AB is about 200 feet high, and the pipe FG about 120; and the condenfation is made in the upper veffel, and communicated

cated to the lower, at the bottom of the mine, by a long pipe. See *WATER-Works*.

55 Laws of hydrostatics applicable to air.

We may now apply to air all the laws of hydrostatics and hydraulics, in perfect confidence that their legitimate consequences will be observed in all its situations. We shall in future substitute, in place of any force acting on a surface of air, a column of water, mercury, or any other fluid whose weight is equal to this force: and as we know distinctly from theory what will be the consequences of this hydrostatic pressure, we shall determine *à priori* the phenomena in air; and in cases where theory does not enable us to say with precision what is the effect of this pressure, experience informs us in the case of water, and analogy enables us to transfer this to air. We shall find this of great service in some cases, which otherwise are almost desperate in the present state of our knowledge.

56 More refined experiments, such as

From such familiar and simple observations and experiments, the fluidity, the heaviness, and elasticity, are discovered of the substance with which we are surrounded, and which we call *air*. But to understand these properties, and completely to explain their numerous and important consequences, we must call in the aid of more refined observations and experiments, which even this scanty knowledge of them enables us to make; we must contrive some methods of producing with precision any degree of condensation. or rarefaction, of employing or excluding the gravitating pressure of air, and of modifying at pleasure the action of all its mechanical properties.

57 a method of compressing the air by Plate CCCCXXIV. Fig. 10.

Nothing can be more obvious than a method of compressing a quantity of air to any degree. Take a cylinder or prismatic tube AB (fig. 10.) shut at one end, and fit it with a piston or plug C, so nicely that no air can pass by its sides. This will be best done in a cylindric tube by a turned stopper, covered with oiled leather, and fitted with a long handle CD. When this is thrust down, the air which formerly occupied the whole capacity of the tube is *condensed* into less room. The force necessary to produce any degree of compression may be concluded from the weight necessary for pushing down the plug to any depth. But this instrument leaves us little opportunity of making interesting experiments on or in this condensed air; and the force required to make any degree of compression cannot be measured with much accuracy; because the piston must be very close, and have great friction, in order to be sufficiently tight: And as the compression is increased, the leather is more squeezed to the side of the tube; and the proportion of the external force, which is employed merely to overcome this variable and uncertain friction, cannot be ascertained with any tolerable precision. To get rid of these imperfections, the following addition may be made to the instrument, which then becomes what is called the *condensing syringe*.

58 the condensing syringe with

The end of the syringe is perforated with a very small hole *e f*; and being externally turned to a small cylinder, a narrow slip of bladder, or of thin leather, soaked in a mixture of oil and tallow, must be tied over the hole. Now let us suppose the piston pushed down to the bottom of the barrel to which it applies close; when it is drawn up to the top, it leaves a void behind, and the weight of the external air presses on the slip of bladder, which therefore claps close to the brass, and thus performs the part of a valve, and keeps it close so that no air can enter. But the piston having reached the top of the barrel, a hole F in the side of it is just below the piston, and the air rushes through this hole and fills the barrel. Now push the piston down again, it immediately passes the hole F, and no air escapes through it; it therefore forces open the valve at *f*, and escapes while the piston moves to the bottom.

59 its vessel or receiver.

Now let E be any vessel, such as a glass bottle, having its mouth furnished with a brass cap firmly cemented to it, having a hollow screw which fits a solid screw *p o*, turned on the cylindric nozzle of the syringe. Screw the syringe into this cap, and it is evident that the air forced out of the syringe will be accumulated in this vessel: for upon drawing up the piston the valve *f* always shuts by the elasticity or expanding force of the air in E; and on pushing it down again, the valve will open as soon as the piston has got so far down that the air in the lower part of the barrel is more powerful than the air already in the vessel. Thus at every stroke an additional barrelful of air will be forced into the vessel E; and it will be found, that after every stroke the piston must be farther pushed down before the valve will open. It cannot open till the pressure arising from the elasticity of the air condensed in the barrel is superior to the elasticity of the air condensed in the vessel; that is, till the condensation of the first, or its density, is *somewhat* greater than that of the last, in order to overcome the straining of the valve on the hole and the sticking occasioned by the clammy matter employed to make it air-tight.

60 A different construction of this syringe.

Sometimes the syringe is constructed with a valve in the piston. This piston, instead of being of one piece and solid, consists of two pieces perforated. The upper part *i k n m* is connected with the rod or handle, and has its lower part turned down to a small cylinder, which is screwed into the lower part *k l o n*; and has a perforation *g h* going up in the axis, and terminating in a hole *h* in one side of the rod, a piece of oiled leather is strained across the hole *g*. When the piston is drawn up and a void left below it, the weight of the external air forces it through the hole *h g*, opens the valve *g*, and fills the barrel. Then, on pushing down the piston, the air being squeezed into less room, presses on the valve *g*, shuts it; and none escaping through the piston, it is gradually condensed as the piston descends till it opens the valve *f*, and is added to that already accumulated in the vessel E.

61 Elasticity of the air increased by condensation.

Having in this manner forced a quantity of air into the vessel E, we can make many experiments in it in this state of condensation. We are chiefly concerned at present with the effect which this produces on its elasticity. We see this to be greatly increased; for we find more and more force required for introducing every successive barrelful. When the syringe is unscrewed, we see the air rush out with great violence, and every indication of great expanding force. If the syringe be connected with the vessel E in the same manner as the syringe in N° 17. viz. by interposing a stopcock B between them (see fig. 3.), and if this stopcock have a pipe at its extremity, reaching near to the bottom of the vessel, which is previously half filled with water, we can observe distinctly when the elasticity of the air in the syringe exceeds that of the air in the receiver: for the piston must be pushed down a certain length before the air from the syringe bubbles up through the water, and the

the piſton muſt be farther down at each ſucceſſive ſtroke before this appearance is obſerved. When the air has thus been accumulated in the receiver, it preſſes the ſides of it outward, and will burſt it if not ſtrong enough. It alſo preſſes on the ſurface of the water; and if we now ſhut the cock, unſcrew the ſyringe, and open the cock again, the air will force the water through the pipe with great velocity, cauſing it to riſe in a beautiful jet. When a metal-receiver is uſed, the condenſation may be puſhed to a great length, and the jet will then riſe to a great height; which gradually diminiſhes as the water is expended and room given to the air to expand itſelf. See the figure.

62 A method of judging of the condenſation, &c.

We judge of the condenſation of air in the veſſel E by the number of ſtrokes and the proportion of the capacity of the ſyringe to that of the veſſel. Suppoſe the firſt to be one-tenth of the laſt; then we know, that after 10 ſtrokes the quantity of air in the veſſel is doubled, and therefore its denſity double, and ſo on after any number of ſtrokes. Let the capacity of the ſyringe (when the piſton is drawn to the top) be a, and that of the veſſel be b, and the number of ſtrokes be n, the denſity of air in the veſſel will be $\frac{b+na}{b}$, or $1+\frac{na}{b}$.

63 not perfectly accurate.

But this is on the ſuppoſition that the piſton accurately fills the barrel, the bottom of the one applying cloſe to that of the other, and that no force is neceſſary for opening either of the valves: but the firſt cannot be inſured, and the laſt is very far from being true. In the conſtruction now deſcribed, it will require at leaſt one twentieth part of the ordinary preſſure of the air to open the piſton valve: therefore the air which gets in will want at leaſt this proportion of its complete elaſticity; and there is always a ſimilar part of the elaſticity employed in opening the nozzle valve. The condenſation therefore is never nearly equal to what is here determined.

64 A better method.

It is accurately enough meaſured by a gage fitted to the inſtrument. A glaſs tube GH of a cylindric bore, and cloſe at the end, is ſcrewed into the ſide of the cap on the mouth of the veſſel E. A ſmall drop of water or mercury is taken into this tube by warming it a little in the hand, which expands the contained air, ſo that when the open end is dipped into water, and the whole allowed to cool, the water advances a little into the tube. The tube is furniſhed with a ſcale divided into ſmall equal parts, numbered from the cloſe end of the tube. Since this tube communicates with the veſſel, it is evident that the condenſation will force the water along the tube, acting like a piſton on the air beyond it, and the air in the tube and veſſel will always be of one denſity. Suppoſe the number at which the drop ſtands before the condenſation is made to be c, and that it ſtands at d when the condenſation has attained the degree required, the denſity of the air in the remote end of the gage, and conſequently in the veſſel, will be $\frac{c}{d}$.

65 A variation of it.

Sometimes there is uſed any bit of tube cloſe at one end, having a drop of water in it, ſimply laid into the veſſel E, and furniſhed or not with a ſcale: but this can only be uſed with glaſs veſſels, and theſe are too weak to reſiſt the preſſure ariſing from great condenſation. In ſuch experiments metalline veſſels are uſed, fitted with a variety of apparatus for different experiments. Some of theſe will be occaſionally mentioned afterwards.

66 Syringes for great condenſations.

It muſt be obſerved in this place, that very great condenſations require great force, and therefore ſmall ſyringes. It is therefore convenient to have them of various ſizes, and to begin with thoſe of a larger diameter, which operate more quickly; and when the condenſation becomes fatiguing, to change the ſyringe for a ſmaller.

67 A ſtop-cock between the ſyringe and receiver.

For this reaſon, and in general to make the condenſing apparatus more convenient, it is proper to have a ſtop-cock interpoſed between the ſyringe and the veſſel, or as it is uſually called the receiver. This conſiſts of a braſs pipe, which has a well-ground cock in its middle, and has a hollow ſcrew at one end, which receives the nozzle ſcrew of the ſyringe, and a ſolid ſcrew at the other end, which fits the ſcrew of the receiver. See fig. 3.

68 Inſtances of great condenſation prove

By theſe gages, or contrivances ſimilar to them, we have been able to aſcertain very great degrees of condenſation in the courſe of ſome experiments. Dr Hales found, that when dry wood was put into a ſtrong veſſel, which it almoſt filled, and the remainder was filled with water, the ſwelling of the wood, occaſioned by its imbibition of water, condenſed the air of his gage into the thouſandth of its original bulk. He found that peaſe treated in the ſame way generated elaſtic air, which preſſing on the air in the gage condenſed it into the fifteen hundredth part of its bulk. This is the greateſt condenſation that has been aſcertained with preciſion, although in other experiments it has certainly been carried much farther; but the preciſe degree could not be aſcertained.

69 air and water to be eſſentially different;

The only uſe to be made of this obſervation at preſent is, that ſince we have been able to exhibit air in a denſity a thouſand times greater than the ordinary denſity of the air we breathe, it cannot, as ſome imagine, be only a different form of water; for in this ſtate it is as denſe or denſer than water, and yet retains its great expanſibility.

70 and ſhow the error of ſome opinions reſpecting elaſticity, &c.

Another important obſervation is, that in every ſtate of denſity in which we find it, it retains its perfect fluidity, tranſmitting all preſſures which are applied to it with undiminiſhed force, as appears by the equality conſtantly obſerved between the oppoſing columns of water or other fluid by which it is compreſſed, and by the facility with which all motions are performed in it in the moſt compreſſed ſtates in which we can make obſervations of this kind. This fact is totally incompatible with the opinion of thoſe who aſcribe the elaſticity of air to the ſpringy ramified ſtructure of its particles, touching each other like ſo many pieces of ſponge or foot-balls. A collection of ſuch particles might indeed be pervaded by ſolid bodies with conſiderable eaſe, if they were merely touching each other, and not ſubjected to any external preſſure. But the moment ſuch preſſure is exerted, and the aſſemblage ſqueezed into a ſmaller ſpace, each preſſes on its adjoining particles: they are individually compreſſed, flattened in their touching ſurfaces, and *before the denſity is doubled* they are ſqueezed into the form of perfect cubes, and compoſe a maſs,

maſs, which may indeed propagate preſſure from one place to another in an imperfect manner, and with great diminution of its intenſity, but will no more be fluid than a maſs of ſoft clay. It will be of uſe to keep this obſervation in mind.

71 Conſequences of the air's elaſticity.

We have ſeen the air is heavy and compreſſible, and might now proceed to deduce in order the explanation of the appearances conſequent on each of theſe properties. But, as has been already obſerved, the elaſticity of air modifies the effects of its gravity ſo remarkably, that they would be imperfectly underſtood if both qualities were not combined in our conſideration of either. At any rate, ſome farther conſequences of its elaſticity muſt be conſidered, before we underſtand the means of varying at pleaſure the effects of its gravity.

72 Its great expanſibility

Since air is heavy, the lower ſtrata of a maſs of air muſt ſupport the upper; and, being compreſſible, they muſt be condenſed by their weight. In this ſtate of compreſſion the elaſticity of the lower ſtrata of air acts in oppoſition to the weight of the incumbent air, and balances it. There is no reaſon which would make us ſuppoſe that its expanding force belongs to it only when in ſuch a ſtate of compreſſion. It is more probable, that, if we could free it from this preſſure, the air would expand itſelf into ſtill greater bulk. This is moſt diſtinctly ſeen in the following experiment.

73 proved by experiment. Fig. 11.

Into the cylindric jar ABCD (fig. 11.) which has a ſmall hole in its bottom, and is furniſhed with an air-tight piſton E, put a ſmall flaccid bladder, having its mouth tied tight with a ſtring. Having puſhed the piſton near to the bottom, and noticed the ſtate of the bladder, ſtop up the hole in the bottom of the jar with the finger, and draw up the piſton, which will require a conſiderable force. You will obſerve the bladder ſwell out, as if air had been blown into it; and it will again collapſe on allowing the piſton to deſcend. Nothing can be more unexceptionable than the concluſion from this experiment, that ordinary air is in a ſtate of compreſſion, and that its elaſticity is not limited to this ſtate. The bladder being flaccid, ſhows that the included air is in the ſame ſtate with the air which ſurrounds it; and the ſame muſt be affirmed of it while it ſwells but ſtill remains flaccid. We muſt conclude, that the whole air within the veſſel expands, and continues to fill it, when its capacity has been enlarged. And ſince this is obſerved to go on as long as we give it more room, we conclude, that by ſuch experiments we have not yet given it ſo much room as it can occupy.

74 Attempts to diſcover the limits of this expanſion by

It was a natural object of curioſity to diſcover the limits of this expanſion; to know what was the natural unconſtrained bulk of a quantity of air, beyond which it would not expand though all external compreſſing force were removed. Accordingly philoſophers conſtructed inſtruments for *rarefying* the air. The common water pump had been long familiar, and appeared very proper for this purpoſe. The moſt obvious is the following.

75 a ſyringe; Fig. 12.

Let the barrel of the ſyringe AB (fig. 12.) communicate with the veſſel V, with a ſtopcock C between them. Let it commuinicate with the external air by another orifice D, in any convenient ſituation, alſo furniſhed with a ſtopcock. Let this ſyringe have a piſton very accurately fitted to it ſo as to touch the bottom all over when puſhed down, and have no vacancy about the ſides.

76 from the operation of which

Now, ſuppoſe the piſton at the bottom, the cock C open, and the cock D ſhut, draw the piſton to the top. The air which filled the veſſel V will expand ſo as to fill both that veſſel and the barrel AB; and as no reaſon can be given to the contrary, we muſt ſuppoſe that the air will be uniformly diffuſed through both. Calling V and B the capacity of the veſſel and barrel, it is plain that the bulk of the air will now be V+B; and ſince the quantity of matter remains the ſame, and the denſity of a fluid is as its quantity of matter directly and its bulk inverſely, the denſity of the expanded air will be $\frac{V}{V+B}$, the denſity of common air being 1: for $V+B : V = 1 : \frac{V}{V+B}$.

77 we infer the diminution of the elaſticity of expanded air,

The piſton requires force to raiſe it, and it is raiſed in oppoſition to the preſſure of the incumbent atmoſphere; for this had formerly been balanced by the elaſticity of the common air: and we conclude from the fact, *that force is required to raiſe the piſton*, that the elaſticity of the expanded air is leſs than that of air in its ordinary ſtate; and an accurate obſervation of the force neceſſary to raiſe it would ſhow how much the elaſticity is diminiſhed. When therefore the piſton is let go, it will deſcend as long as the preſſure of the atmoſphere exceeds the elaſticity of the air in the barrel; that is, till the air in the barrel is in a ſtate of ordinary denſity. To put it further down will require force, becauſe the air muſt be compreſſed in the barrel; but if we open the cock D, the air will be expelled through it, and the piſton will reach the bottom.

78 and calculate its denſity.

Now ſhut the *diſcharging cock* D, and open the cock C, and draw up the piſton. The air which occupied the ſpace V, with the denſity $\frac{V}{V+B}$, will now occupy the ſpace V+B, if it expands ſo far. To have its denſity D, ſay, As its preſent bulk V+B is to its former bulk V, ſo is its former denſity $\frac{V}{V+B}$ to its new denſity; which will therefore be $\frac{V+V}{\overline{V+B}\times\overline{V+B}}$, or $\left.\overline{\frac{V}{V+B}}\right|^{2}$.

79 It is evident, that if the air continues to expand, the denſity of the air in the veſſel after the third drawing up of the piſton will be $\left.\overline{\frac{V}{V+B}}\right|^{3}$, after the fourth it will be $\left.\overline{\frac{V}{V+B}}\right|^{4}$, and after any number of ſtrokes n will be $\left.\overline{\frac{V}{V+B}}\right|^{n}$. Thus, if the veſſel is four times as large as the barrel, the denſity after the fifth ſtroke will be $\frac{1024}{3125}$, nearly $\frac{1}{3}$ of its ordinary denſity.

80 On the other hand, the number n of ſtrokes neceſſary for reducing air to the denſity D is $\frac{\text{Log } D}{\text{Log } V - \text{Log } (V+B)}$.

81 Some inconveniences of this inſtrument.

Thus we ſee that this inſtrument can never abſtract the whole air in conſequence of its expanſion, but only rarefy it continually as long as it continues to expand; nay, there is a limit beyond which the rarefaction cannot

not go. When the piston has reached the bottom, there remains a small space between it and the cock C filled with common air. When the piston is drawn up, this small quantity of air expands, and also a similar quantity in the neck of the other cock; and no air will come out of the receiver V till the expanded air in the barrel is of a smaller density than the air in the receiver. This circumstance evidently directs us to make these two spaces as small as possible, or by some contrivance to fill them up altogether. Perhaps this may be done effectually in the following manner.

82 Remedied by another, Fig. 13. Let BE (fig. 13.) represent the bottom of the barrel, and let the circle HKI be the section of the key of the cock, of a large diameter, and place it as near to the barrel as can be. Let this communicate with the barrel by means of a hole FG widening upwards, as the frustum of a hollow obtuse cone. Let the bottom of the piston *b f h g e* be shaped so as to fit the bottom of the barrel and this hole exactly. Let the cock be pierced with two holes. One of them, HI, passes, perpendicularly through its axis, and forms the communication between the receiver and barrel. The other hole, KL, has one extremity K on the same circumference with H, so that when the key is turned a fourth part round, K will come into the place of H: but this hole is pierced obliquely into the key, and thus keeps clear of the hole HI. It goes no further than the axis, where it communicates with a hole bored along the axis and terminating at its extremity. This hole forms the communication with the external air, and serves for discharging the air in the barrel. (A side view of the key is seen in fig. 14.). Fig. 12. shows the position of the cock while the piston is moving upwards, and fig. 14. shows its position while the piston is moving downwards. When the piston has reached the bottom, the conical piece *f h g* of the piston, which may be of firm leather, fills the hole FHG, and therefore completely expels the air from the barrel. The canal KL *l* of the cock contains air of the common density; but this is turned aside into the position KL (fig. 13.), while the piston is still touching the cock. It cannot extend into the barrel during the ascent of the piston. In place of it the perforation HLI comes under the piston, filled with air that had been turned aside with it when the piston was at the top of the barrel, and therefore of the same density with the air of the receiver. It appears therefore that there is no limit to the rarefaction as long as the air will expand.

Fig. 14.

83 called an *exhausting syringe.* This instrument is called an Exhausting Syringe. It is more generally made in another form, which is much less expensive, and more convenient in its use. Instead of being furnished with *cocks* for establishing the communications and shutting them, as is necessary, it has *valves* like those of the condensing syringe, but opening in the opposite direction. It is thus made:

84 Its construction and Fig. 15. The pipe of communication or conduit MN (fig. 15.) has a male screw in its extremity, and over this is tied a slip of bladder or leather M. The lower half of the piston has also a male screw on it, covered at the end with a slip of bladder O. This is screwed into the upper half of the piston, which is pierced with a hole H coming out of the side of the rod.

85 operation. Now suppose the syringe screwed to the conducting pipe, and that screwed into the receiver V, and the piston at the bottom of the barrel. When the piston is drawn up, the pressure of the external air shuts the valve O, and a void is left below the piston: there is therefore no pressure on the upper side of the valve M to balance the elasticity of the air in the receiver which formerly balanced the weight of the atmosphere. The air therefore in the receiver lifts this valve, and distributes itself between the vessel and the barrel; so that when the piston has reached the top the density of the air in both receiver and barrel is as before $\frac{V}{V+B}$.

When the piston is let go it descends, because the elasticity of the expanded air is not a balance for the pressure of the atmosphere, which therefore presses down the piston with the difference, keeping the piston-valve shut all the while. At the same time the valve M also shuts: for it was opened by the prevailing elasticity of the air in the receiver, and while it is open the two airs have equal density and elasticity; but the moment the piston descends, the capacity of the barrel is diminished, the elasticity of its air increases by collapsing, and now prevailing over that of the air in the receiver shuts the valve M. 86

When it has arrived at such a part of the barrel that the air in it is of the density of the external air, there is no force to push it farther down; the hand must therefore press it. This attempts to condense the air in the barrel, and therefore increases its elasticity; so that it lifts the valve O and escapes, and the piston gets to the bottom. When drawn up again, greater force is required than the last time, because the elasticity of the included air is less than in the former stroke. The piston rises further before the valve M is lifted up, and when it has reached the top of the barrel the density of the included air is $\left|\frac{V}{V+B}\right|^4$. The piston, when let go, will descend further than it did before ere the piston-valve open, and the pressure of the hand will again push it to the bottom, all the air escaping through O. The rarefaction will go on at every successive stroke in the same manner as with the other syringe. 87

This syringe is evidently more easy in its use, requiring no attendance to the cocks to open and shut them at the proper times. On this account this construction of an exhausting syringe is much more generally used. 88 Advantages of this syringe over the former, and

But it is greatly inferior to the syringe with cocks with respect to its power of rarefaction. Its operation is greatly limited. It is evident that no air will come out of the receiver unless its elasticity *exceed* that of the air in the barrel by a difference able to lift up the valve M. A piece of oiled leather tied across this hole can hardly be made tight and certain of clapping to the hole without some small straining, which must therefore be overcome. It must be very gentle indeed not to require a force equal to the weight of two inches of water, and this is equal to about the 200th part of the whole elasticity of the ordinary air; and therefore this syringe, for this reason alone, cannot rarefy air above 200 times, even though air were capable of an indefinite expansion. In like manner the valve O cannot be raised without a similar prevalence of the elasticity of the air in the barrel above the weight of the atmosphere. These causes united, make it difficult to rarefy the air more than 100 times, and very few such syringes will rarefy 89 its inferiority.

rarefy it more than 50 times; whereas the syringe with cocks, when new and in good order, will rarefy it 1000 times.

90 The former syringe, however, more liable to go out of order.

But, on the other hand, syringes with cocks are much more expensive, especially when furnished with apparatus for opening and shutting the cocks. They are more difficult to make equally tight, and (which is the greatest objection) do not remain long in good order. The cocks, by so frequently opening and shutting, grow loose, and allow the air to escape. No method has been found of preventing this. They must be ground tight by means of emery or other cutting powders. Some of these unavoidably stick in the metal, and continue to wear it down. For this reason philosophers, and the makers of philosophical instruments, have turned their chief attention to the improvement of the syringe with valves. We have been thus minute in the account of the operation of rarefaction, that the reader may better understand the value of these improvements, and in general the operation of the principal pneumatic engines.

Of the Air-Pump.

91 Invention of the air-pump by Guericke.

An Air-Pump is nothing but an exhausting syringe accommodated to a variety of experiments. It was first invented by Otto Guericke, a gentleman of Magdeburgh in Germany, about the year 1654. We trust that it will not be unacceptable to our readers to see this instrument, which now makes a principal article in a philosophical apparatus, in its first form, and to trace it through its successive steps to its present state of improvement.

Guericke, indifferent about the solitary possession of an invention which gave entertainment to numbers who came to see his wonderful experiments, gave a minute description of all his pneumatic apparatus to Gaspar Schottus professor of mathematics at Wirtemberg, who immediately published it with the author's consent, with an account of some of its performances, first in 1657, in his *Mechanica Hydraulico-pneumatica*; and then in his *Technica Curiosa*, in 1664, a curious collection of all the wonderful performances of art which he collected by a correspondence over all Europe.

92 Construction of his pump. Fig. 16.

Otto Guericke's air-pump consists of a glass receiver A (fig. 16.) of a form nearly spherical, fitted up with a brass cap and cock B. The nozzle of the cap was fixed to a syringe CDE, also of brass, bent at D into half a right angle. This had a valve at D, opening from the receiver into the syringe, and shutting when pressed in the opposite direction. In the upper side of the syringe there is another valve F, opening from the syringe into the external air, and shutting when pressed inwards. The piston had no valve. The syringe, the cock B, and the joint of the tube, were immersed in a cistern filled with water. From this description it is easy to understand the operation of the instrument. When the piston was drawn up from the bottom of the syringe, the valve F was kept shut by the pressure of the external air, and the valve D opened by the elasticity of the air in the receiver. When it was pushed down again, the valve D immediately shut by the superior elasticity of the air in the syringe; and when this was sufficiently compressed, it opened the valve F, and was discharged. It was immersed in water, that no air might find its way through the joints or cocks.

Air-pump.

93 Its imperfections.

It would seem that this machine was not very perfect, for Guericke says that it took several hours to produce an evacuation of a moderate-sized vessel; but he says, that when it was in good order, the rarefaction (for he acknowledges that it was not, nor could be, a complete evacuation) was so great, that when the cock was opened, and water admitted, it filled the receiver so as sometimes to leave no more than the bulk of a pea filled with air. This is a little surprising; for if the valve F be placed as far from the bottom of the syringe as in Schottus's figure, it would appear that the rarefaction could not be greater than what must arise from the air in DF expanding till it filled the whole syringe: because as soon as the piston in its descent passes F it can discharge no more air, but must compress it between F and the bottom, to be expanded again when the piston is drawn up. It is probable that the piston was not very tight, but that on pressing it down it allowed the air to pass it; and the water in which the whole was immersed prevented the return of the air when it was drawn up again: and this accounts for the great time necessary for producing the desired rarefaction.

94 His improvement of it. Fig. 17.

Guericke, being a gentleman of fortune, spared no expence, and added a part to the machine, which saved his numerous visitants the trouble of hours attendance before they could see the curious experiments with the rarefied air. He made a large copper vessel G (fig. 17.), having a pipe and cock below, which passed through the floor of the chamber into an under apartment, where it was joined to the syringe immersed in the cistern of water, and worked by a lever. The upper part of the vessel terminated in a pipe, furnished with a stopcock H, surrounded with a small brim to hold water for preventing the ingress of air. On the top was another cap I, also filled with water, to protect the junction of the pipes with the receiver K. This great vessel was always kept exhausted, and workmen attended below. When experiments were to be performed in the receiver K, it was set on the top of the great vessel, and the cock H was opened. The air in K immediately diffused itself equally between the two vessels, and was so much more rarefied as the receiver K was smaller than the vessel G. When this rarefaction was not sufficient, the attendants below immediately worked the pump.

These particulars deserve to be recorded, as they show the inventive genius of this celebrated philosopher, and because they are useful even in the present advanced state of the study. Guericke's method of excluding air from all the joints of his apparatus, by immersing these joints in water, is the only method that has to this day been found effectual; and there frequently occur experiments where this exclusion for a long time is absolutely necessary. In such cases it is necessary to construct little cups or cisterns at every joint, and to fill them with water or oil. In a letter to Schottus, 1662-3, he describes very ingenious contrivances for producing complete rarefaction after the elasticity of the remaining air has been so far diminished that it is not able to open the valves. He opens the exhausting valves by a plug, which is pushed in by the hand; and the discharging valve is opened by a small pump placed on its outside, so that it opens into a void instead of opening against the pressure

Air-pump.

pressure of the atmosphere. (See *Schotti Technica Curiosa*, p. 68. 70.). These contrivances have been lately added to air-pumps by Haas and Hurter as new inventions.

It must be acknowledged, that the application of the pump or syringe to the exhaustion of air was a very obvious thought on the principle exhibited in N° 17. and in this way it was also employed by Guericke, who first filled the receiver with water, and then applied the syringe. But this was by no means either his object or his principle. His object was not solely to procure a vessel void of air, but to exhaust the air which was already in it; and his principle was the power which he suspected to be in air of expanding itself into a greater space when the force was removed which he supposed to compress it. He expressly says (*Tract. de Experimentis Magdeburgicis, et in Epist. ad Schottum*), that the contrivance occurred to him accidentally when occupied with experiments in the Toricellian tube, in which he found that the air would really expand, and completely fill a much larger space than what it usually occupied, and that he had found no limits to the expansion, evincing this by facts which we shall perfectly understand by and by. This was a doctrine quite new, and required a philosophical mind to view it in a general and systematic manner; and it must be owned that his manner of treating the subject is equally remarkable for ingenuity and for modesty. (*Epist. ad Schottum*).

95 Merits of Guericke.

96 Progress of experimental philosophy.

His doctrine and his machine were soon spread over Europe. It was the age of literary ardour and philosophical curiosity; and it is most pleasant to us, who, standing on the shoulders of our predecessors, can see far around us, to observe the eagerness with which every new, and to us frivolous, experiment was repeated and canvassed. The worshippers of Aristotle were daily receiving severe mortifications from the experimenters, or empirics as they affected to call them, and they exerted themselves strenuously in support of his now tottering cause. This contributed to the rapid propagation of every discovery; and it was a most profitable and respectable business to go through the chief cities of Germany and France exhibiting philosophical experiments.

97 Ardour of Mr Boyle.

About this time the foundations of the Royal Society of London were laid. Mr Boyle, Mr Wren, Lord Brounker, Dr Wallis, and other curious gentlemen, held meetings at Oxford, in which were received accounts of whatever was doing in the study of nature; and many experiments were exhibited. The researches of Galileo, Toricelli, and Paschal, concerning the pressure of the air, greatly engaged their attention, and many additions were made to their discoveries. Mr Boyle, the most ardent and successful studier of nature, had the principal share in these improvements, his inquisitive mind being aided by an opulent fortune. In a letter to his nephew Lord Dungarvon, he says that he had made many attempts to see the appearances exhibited by bodies freed from the pressure of the air. He had made Toricellian tubes, having a small vessel a-top, into which he put some bodies before filling the tubes with mercury; so that when the tube was set upright, and the mercury run out, the bodies were *in vacuo*. He had also abstracted the water from a vessel, by a small pump, by means of its weight, in the manner described in N° 17, having previously put bodies into the vessel along with the water. But all these ways were very troublesome and imperfect. He was delighted when he learned from Schottus's first publication, that Counsellor Guericke had effected this by the expansive power of the air; and immediately set about constructing a machine from his own ideas, no description of Guericke's being then published.

Plate CCCCXXV. Fig. 18.

It consisted of a receiver A (fig. 18.), furnished with a stopcock B, and syringe CD placed in a vertical position below the receiver. Its valve C was in its bottom, close adjoining to the entry of the pipe of communication; and the hole by which the air issued was farther secured by a plug which could be removed. The piston was moved by a wheel and rackwork. The receiver of Guericke's pump was but ill adapted for any considerable variety of experiments; and accordingly very few were made in it. Mr Boyle's receiver had a large opening EF, with a strong glass margin. To this was fitted a strong brass cap, pierced with a hole G in its middle, to which was fitted a plug ground into it, and shaped like the key of a cock. The extremity of this key was furnished with a screw, to which could be affixed a hook, or a variety of pieces for supporting what was to be examined in the receiver, or for producing various motions within it, without admitting the air. This was farther guarded against by means of oil poured round the key, where it was retained by the hollow cup-like form of the cover. With all these precautions, however, Mr Boyle ingenuously confesses, that it was but seldom, and with great difficulty, that he could produce an extreme degree of rarefaction; and it appears by Guericke's letter to Schottus, that in this respect the Magdeburgh machine had the advantage. But most of Boyle's very interesting experiments did not require this extreme rarefaction; and the variety of them, and their philosophic importance, compensated for this defect, and soon eclipsed the fame of the inventor to such a degree, that the state of air in the receiver was generally denominated the *vacuum Boyleanum*, and the air-pump was called *machina Boyleana*. It does not appear that Guericke was at all solicitous to maintain his claim to priority of invention. He appears to have been of a truly noble and philosophical mind, aiming at nothing but the advancement of science.

98 His air-pump.

99 His contrivances to make air-vessels tight.

Mr Boyle found, that to make a vessel air-tight, it was sufficient to place a piece of wet or oiled leather on its brim, and to lay a flat plate of metal upon this. The pressure of the external air squeezed the two solid bodies so hard together, that the soft leather effectually excluded it. This enabled him to render the whole machine incomparably more convenient for a variety of experiments. He caused the conduit-pipe to terminate in a flat plate which he covered with leather, and on this he set the glass ball or receiver, which had both its upper and lower brim ground flat. He covered the upper orifice in like manner with a piece of oiled leather and a flat plate, having cocks and a variety of other perforations and contrivances suited to his purposes. This he found infinitely more expeditious, and also tighter, than the clammy cements which he had formerly used for securing the joints.

100 Dr Hooke's improvement of Boyle's air-pump.

He was now assisted by Dr Hooke, the most ingenious and inventive mechanic that the world has ever seen. This person made a great improvement on the air-pump, by applying two syringes whose piston-rods were worked by

Air-pump. Fig. 20. by the same wheel, as in fig. 20. and putting valves in the pistons in the same manner as in the piston of a common pump. This evidently doubled the expedition of the pump's operation; but it also greatly diminished the labour of pumping: for it must be observed, that the piston H must be drawn up against the pressure of the external air, and when the rarefaction is nearly perfect this requires a force of nearly 15 pounds for every inch of the area of the piston. Now when one piston H is at the bottom of the barrel, the other K is at the top of the barrel, and the air below K is equally rare with that in the receiver. Therefore the pressure of the external air on the piston K is *nearly* equal to that on the piston H. Both, therefore, are acting in opposite directions on the wheel which gave them motion; and the force necessary for raising H is only the difference between the elasticity of the air in the barrel H and that of the air in the barrel K. This is very small in the beginning of the stroke, but gradually increases as the piston K descends, and becomes equal to the whole excess of the air's pressure above the elasticity of the remaining air of the receiver when the air at K of the natural density begins to open the piston valves. An accurate attention to the circumstances will show us that the force requisite for working the pump is greatest at first, and gradually diminishes as the rarefaction advances; and when this is nearly complete, hardly any more force is required than what is necessary for overcoming the friction of the pistons, except during the discharge of the air at the end of each stroke.

101 Generally adopted.

This is therefore the form of the air-pump which is most generally used all over Europe. Some traces of national prepossession remain. In Germany, air-pumps are frequently made after the original model of Guericke's (Wolff Cyclomathesis); and the French generally use the pump made by Papin, though extremely aukward. We shall give a description of Boyle's air-pump as finally improved by Hawkesbee, which, with some small accommodations to particular views, still remains the most approved form.

102 Hawkesbee's improvements. Fig. 19.

Here follows the description from Desaguliers.

It consists of two brass barrels *aa*, *aa* (fig. 19.), 12 inches high and 2 wide. The pistons are raised and depressed by turning the winch *bb*. This is fastened to an axis passing through a strong toothed wheel, which lays hold of the teeth of the racks *cccc*. Then the one is raised while the other is depressed; by which means the valves, which are made of limber bladder, fixed in the upper part of each piston, as well as in the openings into the bottom of the barrels, perform their office of discharging the air from the barrels, and admitting into them the air from the receiver to be afterwards discharged; and when the receiver comes to be pretty well exhausted of its air, the pressure of the atmosphere in the descending piston is nearly so great, that the power required to raise the other is little more than is necessary for overcoming the friction of the piston, which renders this pump preferable to all others, which require more force to work them as the rarefaction of the air in the receiver advances.

103 Barrels.

The barrels are set in a brass dish about two inches deep, filled with water or oil to prevent the insinuation of air. The barrels are screwed tight down by the nuts *ee*, *ee*, which force the frontispiece *ff* down on them, through which the two pillars *gg*, *gg* pass.

104 Brass pipe, &c.

From between the barrels rises a slender brass pipe *hh*, communicating with each by a perforation in the transverse piece of brass on which they stand. The upper end of this pipe communicates with another perforated piece of brass, which screws on underneath the plate *iiii*, of ten inches diameter, and surrounded with a brass rim to prevent the shedding of water used in some experiments. This piece of brass has three branches: 1st, An horizontal one communicating with the conduit pipe *hh*. 2d, An upright one screwed into the middle of the pump-plate, and terminating in a small pipe *k*, rising about an inch above it. 3d, A perpendicular one, looking downwards in the continuation of the pipe *k*, and having a hollow screw in its end receiving the brass cap of the gage-pipe *llll*, which is of glass, 34 inches long, and immersed in a glass cistern *mm* filled with mercury. This is covered a-top with a cork float, carrying the weight of a light wooden scale divided into inches, which are numbered from the surface of the mercury in the cistern. This scale will therefore rise and fall with the mercury in the cistern, and indicate the true elevation of that in the tube.

105 Stopcock.

There is a stopcock immediately above the insertion of the gage-pipe, by which its communication may be cut off. There is another at *n*, by which a communication is opened with the external air, for allowing its readmission; and there is sometimes another immediately within the insertion of the conduct-pipe for cutting off the communication between the receiver and the pump. This is particularly useful when the rarefaction is to be continued long, as there are by these means fewer chances of the insinuation of air by the many joints.

106 Receivers.

The receivers are made tight by simply setting them on the pump-plate with a piece of wet or oiled leather between; and the receivers which are open a-top, have a brass cover set on them in the same manner. In these covers there are various perforations and contrivances for various purposes. The one in the figure has a slip wire passing through a collar of oiled leather, having a hook or a screw in its lower end for hanging any thing on or producing a variety of motions.

107 Contrivance for removing them.

Sometimes the receivers are set on another plate, which has a pipe screwed into its middle, furnished with a stopcock and a screw, which fits the middle pipe *k*. When the rarefaction has been made in it, the cock is shut, and then the whole may be unscrewed from the pump, and removed to any convenient place. This is called a *transporter plate*.

108 Principle upon which the gage is constructed.

It only remains to explain the gage *llll*. In the ordinary state of the air its elasticity balances the pressure of the incumbent atmosphere. We find this from the force that is necessary to squeeze it into less bulk in opposition to this elasticity. Therefore the elasticity of the air increases with the vicinity of its particles. It is therefore reasonable to expect, that when we allow it to occupy more room, and its particles are farther asunder, its elasticity will be diminished though not annihilated; that is, it will no longer balance the WHOLE pressure of the atmosphere, though it may still balance part of it. If therefore an upright pipe have its lower end immersed in a vessel of mercury, and communicate by its upper end with a vessel containing rarefied, therefore less elastic, air, we should expect that the pressure of the air will prevail, and force the mercury into the tube, and cause it to rise to such a height that the

the weight of the mercury, joined to the elasticity of the rarefied air acting on its upper surface, shall be exactly equal to the whole pressure of the atmosphere. The height of the mercury is the exact measure of that part of the whole pressure which is not balanced by the elasticity of the rarefied air, and its deficiency from the height of the mercury in the Toricellian tube is the exact measure of this remaining elasticity.

109
ſo as to indicate the degree of rarefaction.

It is evident therefore, that the pipe will be a ſcale of the elaſticity of the remaining air, and will indicate in ſome ſort the degree of rarefaction: for there muſt be ſome analogy between the denſity of the air and its elaſticity; and we have no reaſon to imagine that they do not increaſe and diminiſh together, although we may be ignorant of the law, that is, of the change of elaſticity correſponding to a known change of denſity. This is to be diſcovered by experiment; and the air-pump itſelf furniſhes us with the beſt experiments for this purpoſe. After rarefying till the mercury in the gage has attained half the height of that in the Toricellian tube, ſhut the communication with the barrels and gage, and admit the water into the receiver. It will go in till all is again in equilibrio with the preſſure of the atmoſphere; that is, till the air in the receiver has collapſed into its natural bulk. This we can accurately meaſure, and compare with the whole capacity of the receiver; and thus obtain the preciſe degree of rarefaction correſponding to half the natural elaſticity. We can do the ſame thing with the elaſticity reduced to one third, one fourth, &c. and thus diſcover the whole law.

110
Inconveniences of this gage,

This gage muſt be conſidered as one of the moſt ingenious and convenient parts of Hawkeſbee's pump; and it is well diſpoſed, being in a ſituation protected againſt accidents: but it neceſſarily increaſes greatly the ſize of the machine, and cannot be applied to the table-pump, repreſented in fig. 20. When it is wanted here, a ſmall plate is added behind, or between the barrels and receiver; and on this is ſet a ſmall tubulated (as it is termed) receiver, covering a common weather-glaſs tube.—This receiver being rarefied along with the other, the preſſure on the mercury in the ciſtern ariſing from the elaſticity of the remaining air is diminiſhed ſo as to be no longer able to ſupport the mercury at its full height; and it therefore deſcends till the height at which it ſtands puts it in equilibrio with the elaſticity. In this form, therefore, the height of the mercury is directly a meaſure of the remaining elaſticity; while in the other it meaſures the remaining unbalanced preſſure of the atmoſphere. But this gage is extremely cumberſome, and liable to accidents. We are ſeldom much intereſted in the rarefaction till it is great: a contracted form of this gage is therefore very uſeful, and was early uſed. A ſyphon ABCD (fig. 21.), each branch of which is about four inches long, cloſe at A and open at D, is filled with boiling mercury till it occupies the branch AB and a very ſmall part of CD, having its ſurface at O. This is fixed to a ſmall ſtand, and fixed into the receiver, along with the things that are to be exhibited in the rarefied air. When the air has been rarefied till its remaining elaſticity is not able to ſupport the column BA, the mercury deſcends in AB, and riſes in CD, and the remaining elaſticity will always be meaſured by the elevation of the mercury in AB above that in the leg CD. Could the exhauſtion be perfected, the ſurfaces in both legs would be on a level. Another

Fig. 20.

111
remedied.
Fig. 21.

gage might be put into the ſame foot, having a ſmall bubble of air at A. This would move from the beginning of the rarefaction; but our ignorance of the analogy between the denſity and elaſticity hinders us from uſing it as a meaſure of either.

It is enough for our preſent purpoſe to obſerve, that the barometer or ſyphon gage is a perfect indication and meaſure of the performance of an air-pump, and that a pump is (*cæteris paribus*) ſo much the more perfect, as it is able to raiſe the mercury higher in the gage. It is in this way that we diſcover that none can produce a complete exhauſtion, and that their operation is only a very great rarefaction: for none can raiſe the mercury to that height at which it ſtands in the Toricellian tube, well purged of air. Few pumps will bring it within one-tenth of an inch. Hawkeſbee's, fitted up according to his inſtructions, will ſeldom bring it within one-fifth. Pumps with cocks, when conſtructed according to the principles mentioned when ſpeaking of the exhauſting ſyringe, and new and in fine order, will in favourable circumſtances bring it within one-fortieth. None with valves fitted up with wet leather, or when water or volatile fluids are allowed acceſs into any part, will bring it nearer than one-fifth. Nay, a pump of the beſt kind, and in the fineſt order, will have its rarefying power reduced to the loweſt ſtandard, as meaſured by this gage, if we put into the receiver the tenth part of a ſquare inch of white ſheep-ſkin, freſh from the ſhops, or of any ſubſtance equally damp. This is a diſcovery made by means of the improved air-pump, and leads to very extenſive and important conſequences in general phyſics; ſome of which will be treated of under this article: and the obſervation is made thus early, that our readers may better underſtand the improvements which have been made on this celebrated machine.

112
A complete exhauſtion not effected by the air-pump.

It would require a volume to deſcribe all the changes which have been made on it. An inſtrument of ſuch multifarious uſe, and in the hands of curious men, each diving into the ſecrets of nature in his favourite line, muſt have received many alterations and real improvements in many particular reſpects. But theſe are beſide our preſent purpoſe; which is to conſider it merely as a machine for rarefying elaſtic or expanſive fluids. We muſt therefore confine ourſelves to this view of it; and ſhall carefully ſtate to our readers every improvement founded on principle, and on pneumatical laws.

113
Various improvements of this machine,

All who uſed it perceived the limit ſet to the rarefaction by the reſiſtance of the valves, and tried to perfect the conſtruction of the cocks. The abbé Nollet and Graveſande, two of the moſt eminent experimental philoſophers in Europe, were the moſt ſucceſsful.

114
by attempting to perfect the conſtruction of the cocks.

Mr Graveſande juſtly preferred Hooke's plan of a double pump, and contrived an apparatus for turning the cocks by the motion of the pump's handle. This is far from either being ſimple or eaſy in working; and occaſions great jerks and concuſſions in the whole machine. This, however, is not neceſſarily connected with the truly pneumatical improvement. His piſton has no valve, and the rod is connected with it by a ſtirrup D (fig. 22.), as in a common pump. The rod has a cylindric part *cp*, which paſſes through the ſtirrup, and has a ſtiff motion in it up and down of about half an inch; being ſtopped by the ſhoulder *c* above and the nut below. The round plate ſupported by this ſtirrup has a ſhort ſquare tube *nd*, which fits tight into the

115
Graveſande's improvement,

Fig. 22.

Air-pump. the hole of a piece of cork F. The round plate E has a square shank *g*, which goes into the square tube *n d*. A piece of thin leather *f*, soaked in oil, is put between the cork and the plate E, and another between the cork and the plate which forms the sole of the stirrup. All these pieces are screwed together by the nail *e*, whose flat head covers the hole *n*. Suppose, therefore, the piston

116 and manner of using it, touching the bottom of the barrel, and the winch turning to raise it again, the friction of the piston on the barrel keeps it in its place, and the rod is drawn up through the stirrup D. Thus the wheel has liberty to turn about an inch; and this is sufficient for turning the cock, so as to cut off the communication with the external air, and to open the communication with the receiver. This being done, and the motion of the winch continued, the piston is raised to the top of the barrel. When the winch is turned in the opposite direction, the piston remains fixed till the cock is turned, so as to shut the communication with the receiver, and open that with the external air.

117 a useful contrivance. This is a pretty contrivance, and does not at first appear necessary; because the cocks might be made to turn at the beginning and end of the stroke without it. But this is just possible; and the smallest error of adjustment, or wearing of the apparatus, will cause them to be open at improper times. Besides, the cocks are not turned in an instant, and are improperly open during some very small time; but this contrivance completely obviates this difficulty.

118 The cock is precisely similar to that formerly described, having one perforation diametrically through it, and another entering at right angles to this, and after reaching the centre, it passes along the axis of the cock, and comes out to the open air.

119 Its inconveniences, It is evident, that by this construction of the cock, the ingenious improvement of Dr Hooke, by which the pressure of the atmosphere on one piston is made to balance (in great part) the pressure on the other, is given up: for, whenever the communication with the air is opened, it rushes in, and immediately balances the pressure on the upper side of the piston in this barrel; so

120 remedied. that the whole pressure in the other must be overcome by the person working the pump. Gravesande, aware of this, put a valve on the orifice of the cock; that is, tied a slip of wet bladder or oiled leather across it; and now the piston is pressed down, as long as the air in the barrel is rarer than the outward air, in the same manner as when the valve is in the piston itself.

121 Highly extolled, but This is all that is necessary to be described in Mr Gravesande's air-pump. Its performance is highly extolled by him, as far exceeding his former pumps with valves. The same preference was given to it by his successor Muschenbroek. But, while they both prepared the pistons and valves and leathers of the pump, by steeping them in oil, and then in a mixture of water and spirits of wine, we are certain that no just estimate could be made of its performance. For with this preparation it could not bring the gage within one-fifth of an

122 limited in its operations. inch of the barometer. We even see other limits to its rarefaction: from its construction, it is plain that a very considerable space is left between the piston and cock, not less than an inch, from which the air is never expelled; and if this be made extremely small, it is plain that the pump must be worked very slow, otherwise there will not be time for the air to diffuse itself from the receiver into the barrel, especially towards the end, when the expelling force, viz. the elasticity of the remaining air, is very small. There is also the same limit to the rarefaction, as in Hooke's or Hawkesbee's pump, opposed by the valve E, which will not open till the air below the piston is considerably denser than the external air: and this pump soon lost any advantages it possessed when fresh from the workman's hands, by the cock's growing loose and admitting air. It is surprising that Gravesande omitted Hawkesbee's security against this, by placing the barrels in a dish filled with oil; which would effectually have prevented this inconvenience. Air-pump. 123 In one respect inferior to Hawkesbee's.

We must not omit a seemingly paradoxical observation of Gravesande, that in a pump constructed with valves, and worked with a determined uniform velocity, the required degree of rarefaction is sooner produced by short barrels than by long ones. It would require too much time to give a general demonstration of this, but it will easily be seen by an example. Suppose the long barrel to have equal capacity with the receiver, then at the end of the first stroke the air in the receiver will have one-half its natural density. Now, let the short barrels have half this capacity: at the end of the first stroke the density of the air in the receiver is two-thirds, and at the end of the second stroke it is four-ninths, which is less than one-half, and the two strokes of the short barrel are supposed to be made in the same time with one of longest, &c. 124 Advantage of short barrels.

Hawkesbee's pump maintained its pre-eminence without rival in Britain, and generally too on the continent, except in France, where every thing took the *ton* of the Academy, which abhorred being indebted to foreigners for any thing in science, till about the year 1750, when it engaged the attention of Mr John Smeaton, a person of uncommon knowledge, and second to none but Dr Hooke in sagacity and mechanical resource. He was then a maker of philosophical instruments, and made many attempts to perfect the pumps with cocks, but found, that whatever perfection he could bring them to, he could not enable them to preserve it; and he never would sell one of this construction. He therefore attached himself solely to the valve pumps. 125 Smeaton improves the valve-pump

The first thing was to diminish the resistance to the entry of the air from the receiver into the barrels: this he rendered almost nothing, by enlarging the surface on which this feebly elastic air was to press. Instead of making these valves to open by its pressure on a circle of one-twentieth of an inch in diameter, he made the valve-hole one inch in diameter, enlarging the surface 400 times; and, to prevent this piece of thin leather from being burst by the great pressure on it, when the piston in its descent was approaching the bottom of the barrel, he supported it by a delicate but strong grating, dividing the valve-hole like the section of a honey-comb, as represented in fig. 25.; and the ribs of this grating are seen edgewise in fig. 23. at *a b c*. 126 by enlarging the valve-hole, Fig. 25. Fig. 23.

The valve was a piece of thin membrane or oiled silk, gently strained over the mouth of the valve-hole, and tied on by a fine silk thread wound round it in the same manner that the narrow slips had been tied on formerly. This done, he cut with a pointed knife the leather round the edge, nearly four quadrantal arcs, leaving a small tongue between each, as in fig. 25. The strained valve immediately shrinks inwards, as represent- 127 changing the structure of the valve, and Fig. 25.

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Air-pump.

ed by the shaded parts; and the strain by which it is kept down is now greatly diminished, taking place only at the corners. The gratings being reduced nearly to an edge (but not quite, lest they should cut), there is very little pressure to produce adhesion by the clammy oil. Thus it appears, that a very small elasticity of the air in the receiver will be sufficient to raise the valve; and Mr Smeaton found, that when it was not able to do this at first, when only about $\frac{1}{300}$ of the natural elasticity, it would do it after keeping the piston up eight or ten seconds, the air having been all the while undermining the valve, and gradually detaching it from the grating.

128 Increasing the expelling force.

Unfortunately he could not follow this method with the piston valve. There was not room round the rod for such an expanded valve; and it would have obliged him to have a great space below the valve, from which he could not expel the air by the descent of the piston. His ingenuity hit on a way of increasing the expelling force through the common valve: he inclosed the rod of the piston in a collar of leather *l*, through which it moved freely without allowing any air to get past its sides. For greater security, the collar of leather was contained in a box terminating in a cup filled with oil. As this makes a material change in the principle of construction of the air-pump (and indeed of pneumatic engines in general), and as it has been adopted in all the subsequent attempts to improve them, it merits a particular consideration.

129 Structure of his piston for this purpose. Fig. 23.

The piston itself consists of two pieces of brass fastened by screws from below. The uppermost, which is of one solid piece with the rod GH (fig. 23.) is of a diameter somewhat less than the barrel; so that when they are screwed together, a piece of leather soaked in a mixture of boiled oil and tallow, is put between them; and when the piston is thrust into the barrel from above, the leather comes up around the side of the piston, and fills the barrel, making the piston perfectly air-tight. The lower half of the piston projects upwards into the upper, which has a hollow *g b c d* to receive it. There is a small hole through the lower half at *a* to admit the air; and a hole *c d* in the upper half to let it through, and there is a slip of oiled silk strained across the hole *a* by way of valve, and there is room enough left at *b c* for this valve to rise a little when pressed from below. The rod GH passes through the piece of brass which forms the top of the barrel so as to move freely, but without any sensible shake: this top is formed into a hollow box, consisting of two pieces ECDF and CNOD, which screw together at CD. This box is filled with rings of oiled leather exactly fitted to its diameter, each having a hole in it for the rod to pass through. When the piece ECDF is screwed down, it compresses the leathers; squeezing them to the rod, so that no air can pass between them; and, to secure us against all ingress of air, the upper part is formed into a cup EF, which is kept filled with oil.

The top of the barrel is also pierced with a hole LK, which rises above the flat surface NO, and has a slip of oiled silk tied over it to act as a valve; opening when pressed from below, but shutting when pressed from above.

The communication between the barrel and receiver is made by means of the pipe ABPQ; and there goes from the hole K in the top of the barrel a pipe KRST, which either communicates with the open air or with the receiver, by means of the cock at its extremity T. The conduit pipe ABPQ has also a cock at Q, by which it is made to communicate either with the receiver or with the open air. These channels of communication are variously conducted and terminated, according to the views of the maker: the sketch in this figure is sufficient for explaining the principle, and is suited to the general form of the pump, as it has been frequently made by Nairne and other artists in London.

130 Superiority of this construction,

Let us now suppose the piston at the top of the barrel, and that it applies to it all over, and that the air in the barrel is very much rarefied: in the common pump the piston valve is pressed hard down by the atmosphere, and continues shut till the piston gets far down, condenses the air below it beyond its natural state, and enables it to force up the valves. But here, as soon as the piston quits the top of the barrel, it leaves a void behind it; for no air gets in round the piston rod, and the valve at K is shut by the pressure of the atmosphere. There is nothing now to oppose the elasticity of the air below but the stiffness of the valve *b c*; and thus the expelling (or more accurately the liberating) force is prodigiously increased.

131 shown by an example.

The superiority of this construction will be best seen by an example. Suppose the stiffness of the valve equal to the weight of $\frac{1}{10}$ of an inch of mercury, when the barometer stands at 30 inches, and that the pump-gage stands at 29.9; then, in an ordinary pump, the valve in the piston will not rise till the piston has got within the 300th part of the bottom of the barrel, and it will leave the valve-hole filled with air of the ordinary density. But in this pump the valve will rise as soon as the piston quits the top of the barrel; and when it is quite down, the valve-hole *a* will contain only the 300th part of the air which it would have contained in a pump of the ordinary form. Suppose farther, that the barrel is of equal capacity with the receiver, and that both pumps are so badly constructed, that the space left below the piston is the 300th part of the barrel. In the common pump the piston valve will rise no more, and the rarefaction can be carried no farther, however delicate the barrel valve may be; but in this pump the next stroke will raise the gage to 29.95, and the piston valve will again rise as soon as the piston gets half way down the barrel.

The limit to the rarefaction by this pump depends chiefly on the space contained in the hole LK, and in the space *b c d* of the piston. When the piston is brought up to the top, and applied close to it, those spaces remain filled with air of the ordinary density, which will expand as the piston descends, and thus will retard the opening of the piston valve. The rarefaction will stop when the elasticity of this small quantity of air, expanded so as to fill the whole barrel (by the descent of the piston to the bottom), is just equal to the force requisite for opening the piston valve.

132 It is easily worked.

Another advantage attending this construction is, that in drawing up the piston, we are not resisted by the whole pressure of the air; because the air is rarefied above this piston as well as below it, and the piston is in precisely the same state of pressure as if connected with another piston in a double pump. The resistance to the ascent of the piston is the excess of the elasticity of the air above it over the elasticity of the air below: this,

Air-pump.

this, toward the end of the rarefaction, is very ſmall, while the piſton is near the bottom of the barrel, but gradually increaſes as the piſton riſes, and reduces the air above it into ſmaller dimenſions, and becomes equal to the preſſure of the atmoſphere, when the air above the piſton is of the common denſity. If we ſhould raiſe the piſton ſtill farther, we muſt condenſe the air above it: but Mr Smeaton has here made an iſſue for the air by a ſmall hole in the top of the barrel, covered with a delicate valve. This allows the air to eſcape, and ſhuts again as ſoon as the piſton begins to deſcend, leaving almoſt a perfect void behind it as before.

This pump has another advantage. It may be changed in a moment from a rarefying to a condenſing engine, by ſimply turning the cocks at Q and T. While T communicates with the open air and Q with the receiver, it is a rarefying engine or air-pump: but when T communicates with the receiver, and Q with the open air, it is a condenſing engine.

Plate CCCCXXVI Fig. 26.

133 Deſcription of Smeaton's pump.

Fig. 26. repreſents Mr Smeaton's air-pump as it is uſually made by Nairne. Upon a ſolid baſe or table are ſet up three pillars F, H, H: the pillar F ſupports the pump-plate A; and the pillars H, H, ſupport the front or head, containing a braſs cog-wheel, which is turned by the handle B, and works in the rack C faſtened to the upper end of the piſton rod. The whole is ſtill farther ſteadied by two pieces of braſs *c b* and *o k*, which connect the pump-plate with the front, and have perforations communicating between the hole *a* in the middle of the plate and the barrel, as will be deſcribed immediately. DE is the barrel of the pump, firmly fixed to the table by ſcrews thro' its upper flanch: *e f d c* is a ſlender braſs tube ſcrewed to the bottom of the barrel, and to the under hole of the horizontal canal *c b*. In this canal there is a cock which opens a communication between the barrel and the receiver, when the key is in the poſition repreſented here: but when the key is at right angles with this poſition, this communication is cut off. If that ſide of the key which is here drawn next to the pump-plate be turned outward, the external air is admitted into the receiver; but if turned inwards, the air is admitted into the barrel.

g h Is another ſlender braſs pipe, leading from the diſcharging valve at *g* to the horizontal canal *h k*, to the under ſide of which it is ſcrewed faſt. In this horizontal canal there is a cock *n* which opens a paſſage from the barrel to the receiver when the key is in the poſition here drawn; but opens a paſſage from the barrel to the external air when the key is turned outwards, and from the receiver to the external air when the key is turned inwards. This communication with the external air is not immediate but through a ſort of box *i*; the uſe of this box is to receive the oil which is diſcharged through the top valve *g*. In order to keep the pump tight, and in working order, it is proper ſometimes to pour a table-ſpoonful of olive oil into the hole *a* of the pump-plate, and then to work the pump. The oil goes along the conduit *b c d f e*, gets into the barrel and through the piſton-valve, when the piſton is preſſed to the bottom of the barrel, and is then drawn up, and forced through the diſcharging valve *g* along the pipe *g h*, the horizontal paſſage *h n*, and finally into the box *i*. This box has a ſmall hole in its ſide near the top, through which the air eſcapes.

From the upper ſide of the canal *c b* there ariſes a ſlender pipe which bends outward and then turns downwards, and is joined to a ſmall box, which cannot be ſeen in this view. From the bottom of this box proceeds downwards the gage-pipe of glaſs, which enters the ciſtern of mercury G fixed below.

On the upper ſide of the other canal at *o* is ſeen a ſmall ſtud, having a ſhort pipe of glaſs projecting horizontally from it, cloſe by and parallel to the front piece of the pump, and reaching to the other canal. This pipe is cloſe at the farther end, and has a ſmall drop of mercury or oil in it at the end *o*. This ſerves as a gage in condenſing, indicating the degree of condenſation by the place of the drop: For this drop is forced along the pipe, condenſing the air before it in the ſame degree that it is condenſed in the barrel and receiver.

134 Method of joining together the different pipes, &c.

In conſtructing this pump, Mr Smeaton introduced a method of joining together the different pipes and other pieces, which has great advantages over the uſual manner of ſcrewing them together with leather between, and which is now much uſed in hydraulic and pneumatic engines. We ſhall explain this to our readers by a deſcription of the manner in which the exhauſting gage is joined to the horizontal duct *c b*.

Fig. 23.

The piece *h i p*, in fig. 23. is the ſame with the little cylinder obſervable on the upper ſide of the horizontal canal *c d*, in fig. 26. The upper part *h i* is formed into an outſide ſcrew, to fit the hollow ſcrew of the piece *d e e d*. The top of this laſt piece has a hole in its middle, giving an eaſy paſſage to the bent tube *c b a*, ſo as to ſlip along it with freedom. To the end *c* of this bent tube is ſoldered a piece of braſs *c f g*, perforated in continuation of the tube, and having its end ground flat on the top of the piece *h i p*, and alſo covered with a ſlip of thin leather ſtrained acroſs it and pierced with a hole in the middle. (Fig. 26.)

It is plain from this form, that if the ſurface *f g* be applied to the top of *h i*, and the cover *d e e d* be ſcrewed down on it, it will draw or preſs them together, ſo that no air can eſcape by the joint, and this without turning the whole tube *c b a* round, as is neceſſary in the uſual way. This method is now adopted for joining together the conducting pipes of the machines for extinguiſhing fires, an operation which was extremely troubleſome before this improvement.

Fig. 26.

The conduit pipe E *e f c* (fig. 26.) is faſtened to the bottom of the barrel, and the diſcharging pipe *g h* to its top, in the ſame manner. But to return to the gage; the bent pipe *c b a* enters the box *s t* near one ſide, and obliquely, and the gage pipe *q r* is inſerted through its bottom towards the oppoſite ſide. The uſe of this box is to catch any drops of mercury which may ſometimes be daſhed up through the gage pipe by an accidental oſcillation. This, by going through the paſſages of the pump, would corrode them, and would act particularly on the joints, which are generally ſoldered with tin. When this happens to an air-pump, it muſt be cleaned with the moſt ſcrupulous attention, otherwiſe it will be quickly deſtroyed.

135 Great powers of this pump. Fig. 27.

This account of Smeaton's pump is ſufficient for enabling the reader to underſtand its operation and to ſee its ſuperiority. It is reckoned a very fine pump of the ordinary conſtruction which will rarefy 200 times, or raiſe the gage to 29.85, the barometer ſtanding at 30. But Mr Smeaton found, that his pump, even after long uſing, raiſed it to 29.95, which we conſider as equivalent

lent to rarefying 600 times. When in fine order, he found no bounds to its rarefaction, frequently raiſing the gage as high as the barometer; and he thought its performance ſo perfect, that the barometer-gage was not ſufficiently delicate for meaſuring the rarefaction. He therefore ſubſtituted the ſyphon gage already deſcribed, which he gives ſome reaſons for preferring; but even this he found not ſufficiently ſenſible.

136 Another contrivance of Smeaton's Fig. 27.

He contrived another, which could be carried to any degree of ſenſibility. It conſiſted of a glaſs body A (fig. 27.), of a pear ſhape, and was therefore called the pear-gage. This had a ſmall projecting orifice at B, and at the other end a tube CD, whoſe capacity was the hundredth part of the capacity of the whole veſſel. This was ſuſpended at the ſlip-wire of the receiver, and there was ſet below it a ſmall cup with mercury. When the pump was worked, the air in the pear-gage was rarefied along with the reſt. When the rarefaction was brought to the degree intended, the gage was let down till B reached the bottom of the mercury. The external air being now let in, the mercury was raiſed into the pear, and ſtood at ſome height E in the tube CD. The length of this tube being divided into 100 parts, and thoſe numbered from D, it is evident that $\frac{DE}{DB}$ will expreſs the degree of rarefaction which had been produced when the gage was immerſed into the mercury: or if DC be $\frac{1}{100}$ of the whole capacity, and be divided into 100 parts by a ſcale annexed to it, each unit of the ſcale will be $\frac{1}{10000}$ of the whole.

137 very ingenious.

This was a very ingenious contrivance, and has been the means of making ſome very curious and important diſcoveries which at preſent engage the attention of philoſophers. By this gage Mr Smeaton found, that his pump frequently rarefied a thouſand, ten thouſand, nay an hundred thouſand times. But though he in every inſtance ſaw the great ſuperiority of his pump above all others, he frequently found irregularities which he could not explain, and a want of correſpondence between the pear and the barometer gages which puzzled him. The pear-gage frequently indicated a prodigious rarefaction, when the barometer-gage would not ſhow more than 600.

138 It excited the attention of the literary world.

Theſe unaccountable phenomena excited the curioſity of philoſophers, who by this time were making continual uſe of the air-pump in their meteorological reſearches, and much intereſted in every thing connected with the ſtate or conſtitution of elaſtic fluids. Mr Nairne, a moſt ingenious and accurate maker of philoſophical inſtruments, made many curious experiments in the examination and compariſon of Mr Smeaton's pump with thoſe of the uſual conſtruction, attending to every circumſtance which could contribute to the inferiority of the common pumps or to their improvement, ſo as to bring them nearer to this rival machine. This rigorous compariſon brought into view ſeveral circumſtances in the conſtitution of the atmoſpheric air, and its relation to other bodies, which are of the moſt extenſive and important influence in the operations of nature. We ſhall notice at preſent ſuch only as have a relation to the operation of the air-pump in extracting AIR from the receiver.

139 Experiments with it by Mr Nairne

Mr Nairne found, that when a little water, or even bit of paper damped with water, was expoſed under the receiver of Mr Smeaton's air-pump, when in the moſt perfect condition, raiſing the mercury in the barometer-gage to 29.95, he could not make it riſe above 29.8 if Fahrenheit's thermometer indicated the temperature 47°, nor above 29.7 if the thermometer ſtood at 55°; and that to bring the gage to this height and keep it there, the operation of the pump muſt be continued for a long time after the water had diſappeared or the paper become perfectly dry. He found that a drop of ſpirits, or paper moiſtened with ſpirits, could not in thoſe circumſtances allow the mercury in the gage to riſe to near that height; and that ſimilar effects followed from admitting any volatile body whatever into the receiver or any part of the apparatus.

This ſhowed him at once how improper the directions were which had been given by Guericke, Boyle, Graveſande, and others, for fitting up the air-pump for experiment, by ſoaking the leather in water, covering the joints with water, or in ſhort, admitting water or any other volatile body near it. 140 ſhow the impropriety of ſoaking the leather with water,

He therefore took his pumps to pieces, cleared them of all the moiſture which he could drive from them by heat, and then leathered them anew with leather ſoaked in a mixture of olive oil and tallow, from which he had expelled all the water it uſually contains, by boiling it till the firſt frothing was over. When the pumps were fitted up in this manner, he uniformly found that Mr Smeaton's pump rarefied the gage to 29.95, and the beſt common pump to 29.87, the firſt of which he computed to indicate a rarefaction to 600, and the other to 230. But in this ſtate he again found that a piece of damp paper, leather, wood, &c. in the receiver, reduced the performance in the ſame manner as before. 141 and the utility of uſing olive oil and tallow.

But the moſt remarkable phenomenon was, that when he made uſe of the pear-gage with the pump cleared from all moiſture, it indicated the ſame degree of rarefaction with the barometer-gage: but when he expoſed a bit of paper moiſtened with ſpirits, and thus reduced the rarefaction of the pump to what he called 50, the barometer gage ſtanding at 29.4, the pear-gage indicated a rarefaction exceeding 100,000; in ſhort, it was not meaſurable; and this phenomenon was almoſt conſtant. Whenever he expoſed any ſubſtance ſuſceptible of evaporation, he found the rarefaction indicated by the barometer-gage greatly reduced, while that indicated by the pear-gage was prodigiouſly increaſed; and both theſe effects were more remarkable as the ſubject was of eaſier evaporation, or the temperament of the air of the chamber was warmer. 142 A remarkable phenomenon

This uniform reſult ſuggeſted the true cauſe. Water boils at the temperature 212, that is, it is then converted into a vapour which is permanently elaſtic while of that temperature, and its elaſticity balances the preſſure of the atmoſphere. If this preſſure be diminiſhed by rarefying the air above it, a low temperature will not allow it to be converted into elaſtic vapour, and keep it in that ſtate. Water will boil in the receiver of an air-pump at the temperature 96, or even under it. Philoſophers did not think of examining the ſtate of the vapour in temperatures lower than what produced ebullition. But it now appears, that in much lower heats than this the ſuperficial water is converted into elaſtic vapour, which continues to exhale from it as long as the water laſts, and, ſupplying the place of air in the receiver, 143 accounted for.

Air-pump.

receiver, exerts the ſame elaſticity, and hinders the mercury from riſing in the gage in the ſame manner as ſo much air of equal elaſticity would have done.

144 Experiments illuſtrating this account.

When Mr Nairne was exhibiting theſe experiments to the Honourable Henry Cavendiſh in 1776, this gentleman informed him that it appeared from a ſeries of experiments of his father Lord Charles Cavendiſh, that when water is of the temperature 72°, it is converted into vapour, under any preſſure leſs than three-fourths of an inch of mercury, and at 41° it becomes vapour when the preſſure is leſs than one-fourth of an inch. Even mercury evaporates in this manner when all preſſure is removed. A dewy appearance is frequently obſerved covering the inſide of the tube of a barometer, where we uſually ſuppoſe a vacuum. This dew, when viewed through a microſcope, appears to be a ſet of detached globules of mercury, and upon inclining the tube ſo that the mercury may aſcend along it, theſe globules will be all licked up, and the tube become clear. The dew which lined it was the vapour of the mercury condenſed by the ſide of the tube; and it is never obſerved but when one ſide is expoſed to a ſtream of cold air from a window, &c.

To return to the vapour in the air-pump receiver, it muſt be obſerved, that as long as the water continues to yield it, we may continue to work the pump; and it will be continually abſtracted by the barrels, and diſcharged in the form of water, becauſe it collapſes as ſoon as expoſed to the external preſſure. All this while the gage will not indicate any more rarefaction, becauſe the thing immediately indicated by the barometer-gage is *diminiſhed elaſticity*, which does not happen here. When all the water which the temperature of the room can keep elaſtic has evaporated under a certain preſſure, ſuppoſe ½ an inch of mercury, the gage ſtanding at 29.5, the vapour which now fills the receiver expands, and by its diminiſhed elaſticity the gage riſes, and now ſome more water which had been attached to bodies by chemical or corpuſcular attraction is detached, and a new ſupply continues to ſupport the gage at a greater height; and this goes on continually till *almoſt* all has been abſtracted: but there will remain ſome which no art can take away; for as it paſſes through the barrels, and gets between the piſton and the top, it ſucceſſively collapſes into water during the aſcent of the piſton, and again expands into vapour when we puſh the piſton down again. Whenever this happens there is an end of the rarefaction.

145 Air and vapour not uniformly mixed together.

While this operation is going on, the air comes out along with the vapour; but we cannot ſay in what proportion. If it were always uniformly mixed with the vapour, it would diminiſh rapidly; but this does not appear to be the caſe. There is a certain period of rarefaction in which a tranſient cloudineſs is perceived in the receiver. This is watery vapour formed at that degree of rarefaction, mingled with, but not diſſolved in or united with, the air, otherwiſe it would be tranſparent. A ſimilar cloud will appear if damp air be admitted ſuddenly into an exhauſted receiver. The vapour, which formed an uniform tranſparent maſs with the air, is either ſuddenly expanded and thus detached from the other ingredient, or is ſuddenly let go by the air, which expands more than it does. We cannot affirm with probability which of theſe is the caſe: different compoſitions of air, that is, air loaded with vapours from different ſubſtances, exhibit remarkable differences in this reſpect. But we ſee from this and other phenomena, which ſhall be mentioned in their proper places, that the air and vapour are not always intimately united; and therefore will not always be drawn out together by the air-pump. But let them be ever ſo confuſedly blended, we ſee that the air muſt come out along with the vapour, and its quantity remaining in the receiver muſt be prodigiouſly diminiſhed by this aſſociation, probably much more than could be, had the receiver only contained pure air.

146 Conſequences of this different in the pear and barometer gages.

Let us now conſider what muſt happen in the pear-gage. As the air and vapour are continually drawn off from the receiver, the air in the pear expands and goes off with it. We ſhall ſuppoſe that the generated vapour hinders the gage from riſing beyond 29.5. During the continued working of the pump, the air in the pear, whoſe elaſticity is 0.5, ſlowly mixes with the vapour at the mouth of the pear, and the mixture even advances into its inſide, ſo that if the pumping be long enough continued, what is in the pear is nearly of the ſame compoſition with what is in the receiver, conſiſting perhaps of 20 parts of vapour and one part of air, all of the elaſticity of 0.5. When the pear is plunged into the mercury, and the external air allowed to get into the receiver, the mercury riſes in the pear-gage, and leaves not $\frac{1}{60}$, but $\frac{1}{60\times 20}$ or $\frac{1}{1200}$ of it filled with common air, the vapour having collapſed into an inviſible atom of water. Thus the pear-gage will indicate a rarefaction of 1200, while the barometer-gage only ſhowed 60, that is, ſhowed the elaſticity of the included ſubſtance diminiſhed 60 times. The concluſion to be drawn from theſe two meaſures (the one of the rarefaction of air, and the other of the diminution of elaſticity) is, that the matter with which the receiver was filled, immediately before the readmiſſion of the air, conſiſted of one part of incondenſible air, and $\frac{1200}{60}$, or 20 parts of watery vapour.

147 Difficulty in accounting for ſome of theſe conſequences.

The only obſcure part of this account is what relates to the compoſition of the matter which filled the pear-gage before the admiſſion of the mercury. It is not eaſy to ſee how the vapour of the receiver comes in by a narrow mouth while the air is coming out by the ſame paſſage. Accordingly it requires a *very long time* to produce this extreme rarefaction in the pear-gage; and there are great irregularities in any two ſucceeding experiments, as may be ſeen by looking at Mr Nairne's account of them in the Philoſophical Tranſactions, vol. lxvii. Some vapours appear to have mixed much more readily with the air than others; and there are ſome unaccountable caſes where vitriolic acid and ſulphureous bodies were included, in which the diminution of denſity indicated by the pear-gage was uniformly leſs than the diminution of elaſticity indicated by the barometer-gage. It is enough for us at preſent to have eſtabliſhed, by unqueſtionable facts, this production of elaſtic vapour, and the neceſſity of attending to it, both in the conſtruction of the air-pump and in drawing reſults from experiments exhibited in it.

148 The ſuperiority of this pump excites two new improvements.

Mr Smeaton's pump, when in good order, and perfectly free from all moiſture, will in dry weather rarefy air about 600 times, raiſing the barometer-gage to within

Air-pump. in $\frac{1}{20}$ of an inch of a fine barometer. This was a performance ſo much ſuperior to that of all others, and by means of Mr Nairne's experiments opened ſo new a field of obſervation, that the air-pump once more became a capital inſtrument among the experimental philoſophers. The cauſes of its ſuperiority were alſo ſo diſtinct, that artiſts were immediately excited to a farther improvement of the machine; ſo that this becomes a new epoch in its hiſtory.

149 Improvements in this pump attempted

There is one imperfection which Mr Smeaton has not attempted to remove. The diſcharging valve is ſtill opened againſt the preſſure of the atmoſphere. An author of the Swediſh academy adds a ſubſidiary pump to this valve, which exhauſts the air from above it, and thus puts it in the ſituation of the piſton valve. We do not find that this improvement has been adopted ſo as to become general. Indeed the quantity of air which remains in the paſſage to this valve is ſo exceedingly little, that it does not ſeem to merit attention. Suppoſing the valve hole $\frac{1}{20}$ of an inch wide and as deep (and it need not be more), it will not occupy more than $\frac{1}{9600}$ part of a barrel twelve inches long and two inches wide.

150 Mr Smeaton, by his ingenious conſtruction, has greatly diminiſhed, but has not annihilated, the obſtructions to the paſſage of the air from the receiver into the barrel. His ſucceſs encouraged farther attempts. One of the firſt and moſt ingenious was that of Profeſſor Ruſſel of the univerſity of Edinburgh, who about the year 1770 conſtructed a pump in which both cocks and valves were avoided.

151 by Ruſſel, Fig. 28.

The piſton is ſolid, as repreſented in fig. 28. and its rod paſſes through a collar of leather on the top of the barrel. This collar is divided into three portions by two braſs rings *a*, *b*, which leave a very ſmall ſpace round the piſton rod. The upper ring *a* communicates by means of a lateral perforation with the bent tube, *l m n*, which enters the barrel at its middle *n*. The lower ring *b* communicates with the bent tube *c d*, which communicates with the horizontal paſſage *d e*, going to the middle *e* of the pump plate. By the way, however, it communicates alſo with a barometer gage *p o*, ſtanding in a ciſtern of mercury *o*, and covered with a glaſs tube cloſe at the top. Beyond *e*, on the oppoſite circumference of the receiver plate, there is a cock or plug *f* communicating with the atmoſphere.

The piſton rod is cloſely embraced by the three collars of leather; but, as already ſaid, has a free ſpace round it in the two braſs rings. To produce this preſſure of the leathers to the rod, the braſs rings which ſeparate them are turned thinner on the inner ſide, ſo that their croſs ſection along a diameter would be a taper wedge. In the ſide of the piſton rod are two cavities *q r*, *t s*, about one-tenth of an inch wide and deep, and of a length equal to the thickneſs of the two rings *a*, *b*, and the intermediate collar of leathers. Theſe cavities are ſo placed on the piſton-rod, that when the piſton is applied to the bottom of the barrel, the cavity *t s* in the upper end of the rod has its upper end oppoſite to the ring *a*, and its lower end oppoſite to the ring *b*, or to the mouth of the pipe *c d*. Therefore, if there be a void in the barrel, the air from the receiver will come from the pipe *c d*, into the cavity in the piſton rod, and by it will get paſt the collar of leather between the rings, and thus will get into the ſmall interſtice between the rod and the upper ring, and then into the pipe *l m n*, and into the empty barrel. When the piſton is drawn up, the ſolid rod immediately ſhuts up this paſſage, and the piſton drives the air through the diſcharging valve *k*. When it has reached the top of the barrel, and is cloſely applied to it, the cavity *q r* is in the ſituation in which *t s* formerly was, and the communication is again opened between the receiver and the empty barrel, and the air is again diffuſed between them. Puſhing down the piſton expels the air by the lower diſcharging pipe and valve *h i*; and thus the operation may be continued.

This muſt be acknowledged to be a moſt ſimple and ingenious conſtruction, and can neither be called a cock nor a valve. It ſeems to oppoſe no obſtruction whatever: and it has the ſuperior advantage of rarefying both during the aſcent and the deſcent of the piſton, doubling the expedition of the performance, and the operator is not oppoſed by the preſſure of the atmoſphere except towards the end of each ſtroke. The expedition, however, is not ſo great as one ſhould expect; for nothing is going on while the piſton is in motion, and the operator muſt ſtop a while at the end of each ſtroke, that the air may have time to come through this long, narrow, and crooked paſſage, to fill the barrel. But the chief difficulty which occurred in the execution aroſe from the clammy oil with which it was neceſſary to impregnate the collar of leathers. Theſe were always in a ſtate of ſtrong compreſſion, that they might cloſely graſp the piſton rod, and prevent all paſſage of air during the motion of the piſton. Whenever therefore the cavities in the piſton rod come into the ſituations neceſſary for connecting the receiver and barrel, this oil is ſqueezed into them, and choaks them up. Hence it always happened that it was ſome time after the ſtroke before the air could force its way round the piſton rod, carrying with it the clammy oil which choaked up the tube *l m n*; and when the rarefaction had proceeded a certain length, the diminiſhed elaſticity of the air was not able to make its way through theſe obſtructions. The death of the ingenious author put a ſtop to the improvements by which he hoped to remedy this defect, and we have not heard that any other perſon has ſince attempted it. We have inſerted it here, becauſe its principle of conſtruction is not only very ingenious, but entirely different from all others, and may furniſh very uſeful hints to thoſe who are much engaged in the conſtruction of pneumatic engines.

152 by Haas, and Hurter.

In the 73d volume of the Philoſophical Tranſactions, Mr Tiberius Cavallo has given the deſcription of an air-pump contrived and executed by Meſſrs Haas and Hurter, inſtrument-makers in London, where theſe artiſts have revived Guericke's method of opening the barrel-valve during the laſt ſtrokes of the pump by a force acting from without. We ſhall inſert ſo much of this deſcription as relates to this diſtinguiſhing circumſtance of its conſtruction.

Fig. 29. repreſents a ſection of the bottom of the barrel, where AA is the barrel and BB the bottom, which has in its middle a hollow cylinder CCFF, projecting about half an inch into the barrel at CC, and extending a good way downwards to FF. The ſpace between this projection and the ſides of the barrel is filled up by a braſs ring DD, over the top of which is ſtrained a piece of oiled ſilk EE, which performs the office of a valve, covering the hole CC. But this hole is filled up by a Fig. 29.

piece

Air-pump. piece of brafs, or rather an affemblage of pieces fcrewed together GGHHII. It confifts of three projecting fillets or fhoulders GG, HH, II, which form two hollows between them, and which are filled with rings of oiled leather OO, PP, firmly fcrewed together. The extreme fillets GG, II, are of equal diameter with the infide of the cylinder, fo as to fill it exactly, and the whole ftuffed with oiled leather, flide up and down without allowing any air to pafs. The middle fillet HH is not fo broad, but thicker. In the upper fillet GG there is formed a fhallow difh about $\frac{1}{4}$ of an inch deep and $\frac{3}{4}$ wide. This difh is covered with a thin plate, pierced with a grating like Mr Smeaton's valve-plate. There is a perforation VX along the axis of this piece, which has a paffage out at one fide H, through the middle fillet. Oppofite to this paffage, and in the fide of the cylinder CCFF, is a hole M, communicating with the conduit pipe MN, which leads to the receiver. Into the lower end of the perforation is fcrewed the pin KL, whofe tail L paffes through the cap FF. The tail L is connected with a lever RQ, moveable round the joint Q. This lever is pufhed upwards by a fpring, and thus the whole piece which we have been defcribing is kept in contact with the flip of oiled filk or valve EE. This is the ufual fituation of things.

153 Now fuppofe a void formed in the barrel by drawing up the pifton; the elafticity of the air in the receiver, in the pipe NM, and in the paffage XV, will prefs on the great furface of the valve expofed through the grating, will raife it, and the pump will perform precifely as Mr Smeaton's does. But fuppofe the rarefaction to have been fo long continued, that the air is no longer able to raife the valve; this will be feen by the mercury rifing no more in the pump-gage. When this is perceived, the operator muft prefs with his foot on the end R of the lever RQ. This draws down the pin KL, and with it the whole hollow plug with its grated top. And thus, inftead of raifing the valve from its plate, the plate is here drawn down from the valve. The air now gets in without any obftruction whatever, and the rarefaction proceeds as long as the pifton rifes. When it is at the top of the barrel, the operator takes his foot from the lever, and the fpring preffes up the plug again and fhuts the valve. The pifton rod paffes through a collar of leather, as in Mr Smeaton's pump, and the air is finally difcharged through an outward valve in the top of the barrel. Thefe parts have nothing peculiar in them.

This is an ingenious contrivance, fimilar to what was adapted by Guericke himfelf; and we have no doubt of thefe pumps performing extremely well if carefully made: and it feems not difficult to keep the plug perfectly airtight by fupplying plenty of oil to the leathers. We cannot fay, however, with precifion what may be expected from it, as no account has been given of its effects befides what Mr Cavallo publifhed in Philofophical Tranfactions 1783, where he only fays, that when it had been long ufed, it had, in the courfe of fome experiments, rarefied 600 times.

154 by Prince, Aiming ftill at the removing the obftructions to the entry of the air from the receiver into the barrels, Mr Prince, an American, has conftructed a pump in which there is no valve or cock whatever between them. In this pump the pifton rod paffes through a collar of leathers, and the air is finally difcharged through a valve, as in the two laft. But we are chiefly to attend, in this place, to the communication between the barrel and the receiver. The barrel widens below into a fort of ciftern ABCD (fig. 30.), communicating with the receiver by the pipe EF. As foon, therefore, as the pifton gets into this wider part, where there is a vacancy all round it, the air of the receiver expands freely through the paffage FEE into the barrel, in which the defcent of the pifton had made a void. When the pifton is again drawn up, as foon as it gets into the cylindric part of the barrel, which it exactly fills, it carries up the air before it, and expels it by the top valve; and, that this may be done more completely, this valve opens into a fecond barrel or air-pump whofe pifton is rifing at the fame time, and therefore the valve of communication (which is the difcharging valve of the primary pump) opens with the fame facility as Mr Smeaton's pifton valve. While the pifton is rifing, the air in the receiver expands into the barrel; and when the pifton defcends, the air in the barrel again collapfes till the pifton gets again into the ciftern, when the air paffes out, and fills the evacuated barrel, to be expelled by the pifton as before. Fig. 30.

No diftinct account has as yet been given of the performance of this pump. We only learn that great inconveniences were experienced from the ofcillations of the mercury in the gage. As foon as the pifton comes into the ciftern, the air from the receiver immediately rufhes into the barrel, and the mercury fhoots up in the gage, and gets into a ftate of ofcillation. The fubfequent rife of the pifton will frequently keep time with the fecond ofcillation, and increafe it. The defcent of the pifton produces a downward ofcillation, by allowing the air below it to collapfe; and, by improperly timing the ftrokes, this ofcillation becomes fo great as to make the mercury enter the pump. To prevent this, and a greater irregularity of working as a condenfer, valves were put in the pifton: but as thefe require force to open them, the addition feemed rather to increafe the evil, by rendering the ofcillations more fimultaneous with the ordinary rate of working. If this could be got over, the conftruction feems very promifing.

It appears, however, of very difficult execution. It has many long, flender, and crooked paffages, which muft be drilled through broad plates of brafs, fome of them appearing fcarcely practicable. It is rare to find plates and other pieces of brafs without air-holes, which it would be very difficult to find out and to clofe; and it muft be very difficult to clear it of obftructions; fo that it appears rather a fuggeftion of theory than a thing warranted by its actual performance.

155 by Lavoifier, Mr Lavoifier, or fome of the naturalifts who were occupied in concert with him in the inveftigation of the different fpecies of gas which are difengaged from bodies in the courfe of chemical operations, has contrived an air-pump which has great appearance of fimplicity, and, being very different from all others, deferves to be taken notice of.

It confifts of two barrels *l*, *m*, fig. 31. with folid piftons *k k*. The pump-plate *a b* is pierced at its centre *c* with a hole which branches towards each of the barrels, as reprefented by *c d*, *c e*. Between the plate and the barrels flides another plate *h i*, pierced in the middle with a branched hole *f d g*, and near the ends with two holes *h h*, *i i*, which go from its under fide to the ends. The holes in thefe two plates are fo adjufted, that when the plate *h i* is drawn fo far towards *h* that the hole *i* comes Fig. 31.

Air-pump. within the barrel *m*, the branch *df* of the hole in the middle plate coincides with the branch *cd* of the upper plate, and the holes *e*, *g* are ſhut. Thus a communication is eſtabliſhed between the barrel *l* and the receiver on the pump-plate, and between the barrel *m* and the external air. In this ſituation the barrel *l* will exhauſt, and *m* will diſcharge. When the piſton of *l* is at its mouth, and that of *m* touches its bottom, the ſliding plate is ſhifted over to the other ſide, ſo that *m* communicates with the receiver through the paſſage *gd*, *ec*, and *l* communicates with the air by the paſſages *h h*.

It is evident that this ſliding plate performs the office of four cocks in a very beautiful and ſimple manner, and that if the piſtons apply cloſe to the ends of the barrels, ſo as to expel the whole air, the pump will be perfect. It works, indeed, againſt the whole preſſure of the external air. But this may be avoided by putting valves on the holes *h*, *i*; and theſe can do no harm, becauſe the air remaining in them never gets back into the barrel till the piſton be at the farther end, and the exhauſtion of that ſtroke completed. But the beſt workmen of London think that it will be incomparably more difficult to execute this cock (for it is a cock of an unuſual form), in ſuch a manner that it ſhall be air-tight and yet move with tolerable eaſe, and that it is much more liable to wearing looſe than common cocks. No accurate accounts have been received of its performance. It muſt be acknowledged to be ingenious, and it may ſuggeſt to an intelligent artiſt a method of combining common conical cocks upon one axis ſo as to anſwer the ſame purpoſes much more effectually; for which reaſon we have inſerted it here.

156 and by Cuthbertſon. The laſt improvement which we ſhall mention is that publiſhed by Mr Cuthbertſon philoſophical inſtrument-maker in Amſterdam. His pump has given ſuch evidences of its perfection, that we can hardly expect or wiſh for any thing more complete. But we muſt be allowed to obſerve, beforehand, that the ſame conſtruction was invented, and, in part, executed before the end of 1779, by Dr Daniel Rutherford, now profeſſor of botany in the univerſity of Edinburgh, who was at that time engaged in experiments on the production of air during the combuſtion of bodies in contact with nitre, and who was vaſtly deſirous of procuring a more complete abſtraction of pure aerial matter than could be effected by Mr Smeaton's pump. The compiler of this article had then an opportunity of peruſing the Doctor's diſſertation on this ſubject, which was read in the Philoſophical Society of Edinburgh. In this diſſertation the Doctor appears fully appriſed of the exiſtence of pure vital air in the nitrous acid, as its chief ingredient, and as the cauſe of its moſt remarkable phenomena, and to want but a ſtep to the diſcoveries which have ennobled the name of Mr Lavoiſier. He was particularly anxious to obtain *apart* this diſtinguiſhing ingredient in its compoſition, and, for this purpoſe, to abſtract completely from the veſſel in which he ſubjected it to examination, every particle of elaſtic matter. The writer of this article propoſed to him to cover the bottom of Mr Smeaton's piſton with ſome clammy matter, which ſhould take hold of the bottom valve, and *ſtart it* when the piſton was drawn up. A few days after, the Doctor ſhowed him a drawing of a pump, having a conical metal valve in the bottom, furniſhed with a long ſlender wire, ſliding in the inſide of the piſton-rod with a gentle friction, ſufficient for lifting the valve, and ſecured againſt all chance of failure by a ſpring a-top, which took hold of a notch in the inſide of the piſton-rod about a quarter of an inch from the lower end, ſo as certainly to lift the valve during the laſt quarter of an inch of the piſton's motion. Being an excellent mechanic, he had executed a valve on this principle, and was fully ſatisfied with its performance. But having already confirmed his doctrines reſpecting the nitrous acid by incontrovertible experiments, his wiſhes to improve the air-pump loſt their incitement, and he thought no more of it; and not long after this, the ardour of the philoſophers of the Teylerian Society at Haerlem and Amſterdam excited the efforts of Mr Cuthbertſon, their inſtrument-maker, to the ſame purpoſe, and produced the moſt perfect air-pump that has yet appeared. We ſhall give a deſcription of it, and an account of its performance, in the inventor's own words.

Cuthbertson's Air-Pump.

On Plate CCCCXXVII. fig. 32. is a perſpective view of this pump, with its two principal gages ſcrewed into their places. Theſe need not be uſed together, except in caſes where the utmoſt exactneſs is required. In common experiments one of them is removed, and a ſtop-ſcrew put in its place. When the pear-gage is uſed, a ſmall round plate, on which the receiver may ſtand, muſt be firſt ſcrewed into the hole at A; but this hole is ſtopped on other occaſions with a ſcrew. When all the three gages are uſed, and the receiver is exhauſted, the ſtop-ſcrew B, at the bottom of the pump, muſt be unſcrewed, to admit the air into the receiver; but when they are not all uſed, either of the other ſtop-ſcrews will anſwer this purpoſe. 157 Fig. 32.

Fig. 33. repreſents a croſs-bar for preventing the barrels from being ſhaken by working the pump or by any accident. Its place in fig. 32. is repreſented by the dotted lines. It is confined in its place, and kept cloſe down on the barrels, by two ſlips of wood NN, which muſt be drawn out, as well as the ſcrews OO, when the pump is to be taken aſunder. Fig. 33.

Plate CCCCXXVIII. exhibits a ſection of all the working parts of the pump, except the wheel and rack, in which there is nothing uncommon.

Fig. 34. is a ſection of one of the barrels, with all its internal parts; and fig. 35. 36. 37. and 38. are different parts of the piſton, proportioned to the ſize of the barrel (A) and to one another.

In fig. 34. CD repreſents the barrel, F the collar of leathers, G a hollow cylindrical veſſel to contain oil, R is alſo an oil-veſſel to receive the oil which is drawn, along with the air, through the hole *a a*, when the piſton is drawn upwards; and, when this is full, the oil is carried over with the air, along the tube T, into the oil-veſſel G. *cc* is a wire which is driven upwards from the Fig. 34.

(A) The piſton and barrel are 1.65 inches in diameter, in proportion to which the ſcale is drawn. Figures 35. 36. 37. and 38. are, however, of double ſize.

Air-pump. the hole *a a* by the paſſage of the air; and as ſoon as this has eſcaped, it falls down again by its own weight, ſhuts up the hole, and prevents all return of the air into the barrel. At *d d* are fixed two pieces of braſs, to keep the wire *c c* in a vertical direction, that it may accurately ſhut the hole. H is a cylindrical wire or rod which carries the piſton I, and is made hollow to receive a long wire *g g*, which opens and ſhuts the hole L; and on the other end of the wire O is ſcrewed a nut, which, by ſtopping in the narroweſt part of the hole, prevents the wire from being driven up too far. This wire and ſcrew are more clearly ſeen in fig. 35. and 39.; they ſlide in a collar of leather *r r*, fig. 35. and 38. in the middle piece of the piſton. Fig. 37. and 38. are the two mean parts which compoſe the piſton, and, when the pieces 36. and 39. are added to it, the whole is repreſented by fig. 35. Fig. 38. is a piece of braſs of a conical form, with a ſhoulder at the bottom. A long hollow ſcrew is cut in it, about two-thirds of its length, and the remainder of the hole, in which there is no ſcrew, is of about the ſame diameter with the ſcrewed part, except a thin plate at the end, which is of a width exactly equal to the thickneſs of *g g*. That part of the inſide of the conical braſs in which no thread is cut, is filled with oiled leathers with holes through which *g g* can ſlide ſtiffly. There is alſo a male ſcrew with a hole in it, fitted to *g g*, ſerving to compreſs the leathers *r r*. In fig. 37. *a a a a* is the outſide of the piſton, the inſide of which is turned ſo as exactly to fit the outſide of fig. 38. *b b* are round leathers about 60 in number, *c c* is a circular piece of braſs of the ſize of the leathers, and *d d* is a ſcrew ſerving to compreſs them. The ſcrew at the end of fig. 36. is made to fit the ſcrew in fig. 38. Now if fig. 39. be puſhed into fig. 38. this into fig. 37. and fig. 36. be ſcrewed into the end of fig. 38. theſe will compoſe the whole of the piſton, as repreſented in fig. 34. H in fig. 34. repreſents the ſame part as H in fig. 35. and is that to which the rack is fixed. If, therefore, this be drawn upwards, it will cauſe fig. 38. to ſhut cloſe into fig. 37. and drive out the air above it; and when it is puſhed downward, it will open as far as the ſhoulder *a a* will permit, and ſuffer air to paſs
Fig. 40. through. AA, fig. 40. is the receiver plate, BB is a long ſquare piece of braſs, ſcrewed into the under ſide of the plate, through which a hole is drilled correſponding to that in the centre of the receiver-plates and with three female ſcrews *b*, *b*, *c*.

The rarefaction of the air in the receiver is effected as follows. Suppoſe the piſton at the bottom of the barrel. The inſide of the barrel, from the top of the pi-
Fig. 34. ſton to *a*, fig. 34. contains common air. When the rod is drawn up, the upper part of the piſton ſticks faſt in the barrel till the conical part connected with the rod ſhuts the conical hole, and its ſhoulder applies cloſe to its bottom. The piſton is now ſhut, and therefore the *whole* is drawn up by the rack-work, driving the air before it through the hole *a c*, into the oil-veſſel at R, and out into the room by the tube T. The piſton will then be at the top of the barrel at *a*, and the wire *g g* will ſtand nearly as repreſented in the figure juſt raiſed from the hole L, and prevented from riſing higher by the nut O. During this motion the air will expand in the receiver, and come along the bent tube *m* into the barrel. Thus the barrel will be filled with air, which, as the piſton riſes, will be rarefied in proportion as the capacity of the receiver, pipes, and barrel, is to the barrel alone. Air-pump. When the piſton is moved down again by the rack-work, it will force the conical part fig. 38. out of the hollow part fig. 37. as far as the ſhoulders *a a*; fig. 35. will reſt on *a a* fig. 37. which will then be ſo far open as to permit the air to paſs freely through it, while at the ſame time the end of *g g* is forced againſt the top of the hole, and ſhuts it in order to prevent any air from returning into the receiver. Thus the piſton, moving downwards, ſuffers the air to paſs out between the ſides of fig. 37. and 38.; and, when it is at the bottom of the barrel, will have the column of air above it; and, conſequently, when drawn upwards it will ſhut, and drive out this air, and, by opening the hole L at the ſame time, will give a free paſſage to more air from the receiver. This proceſs being continued, the air of the receiver will be rarefied *as far as its expanſive power will permit*. For in this machine there are no valves to be forced open by the elaſticity of the air in the receiver, which at laſt it is unable to effect. There is therefore nothing to prevent the air from expanding to its utmoſt degree.

It may be ſuſpected here, that as the air muſt eſcape through the diſcharging paſſage *a c*, fig. 34. againſt the preſſure of a column of oil and the weight of the wire, there will remain in this paſſage a quantity of air of conſiderable denſity, which will expand again into the barrel during the deſcent of the piſton, and thus put a ſtop to the progreſs of rarefaction. This is the caſe in Mr Smeaton's pump, and all which have valves in the piſton. But it is the peculiar excellency of this pump, that whatever be the denſity of the air remaining in *a c*, the rarefaction will ſtill go on. It is worth while to be perfectly convinced of this. Let us ſuppoſe that the air contained in *a c* is $\frac{1}{100}$th part of the common air which would fill the barrel, and that the capacity of the barrel is equal to that of the receiver and paſſages, and that the air in the receiver and barrel is of the ſame denſity, the piſton being at the bottom of the barrel: The barrel will therefore contain $\frac{10}{1000}$ parts of its natural quantity, and the receiver $\frac{10}{1000}$. Now let the piſton be drawn up. No air will be diſcharged at *a c*, becauſe it will contain the whole air which was in the barrel, and which has now collapſed into its ordinary bulk. But this does not in the leaſt hinder the air of the receiver from expanding into the barrel, and diffuſing itſelf equally between both. Each will now contain $\frac{5}{1000}$ of their ordinary quantity when the piſton is at the top, and *a c* will contain $\frac{1}{100}$ as before, or $\frac{10}{1000}$. Now puſh down the piſton. The hole L is inſtantly ſhut, and the air in *a c* expands into the barrel, and the barrel now contains $\frac{15}{1000}$. When the piſton has reached the bottom, let it be again drawn up. There will be $\frac{5}{1000}$ diſcharged through *c*, and the air in the receiver will again be equally diſtributed between it and the barrel. Therefore the receiver will now contain $\frac{2\frac{1}{2}}{1000}$. When the piſton reaches the bottom, there will be $\frac{12\frac{1}{2}}{1000}$ in the barrel. When again drawn up to the top, there will be $\frac{2\frac{1}{2}}{1000}$ diſcharged, and the receiver will contain $\frac{1\frac{1}{4}}{1000}$; and when the piſton

Air-pump.

reaches the bottom, there will be $\frac{11\frac{1}{4}}{1000}$. At the next ſtroke the receiver will contain only $\frac{0.\frac{5}{8}}{1000}$, &c. &c.

Thus it appears, that notwithſtanding the $\frac{10}{1000}$ which always expands back again out of the hole *a c* into the barrel, the rarity of the air in the receiver will be doubled at every ſtroke. There is therefore no need of a ſubſidiary air-pump at *c*, as in the American air-pump, and in the Swediſh attempt to improve Smeaton's.

In uſing this air-pump no particular directions are neceſſary, nor is any peculiar care neceſſary for keeping it in order, except that the oil-veſſel A be always kept about half full of oil. When the pump has ſtood long without being uſed, it will be proper to draw a table-ſpoonful of olive-oil through it, by pouring it into the hole in the middle of the receiver-plate when the piſton is at the bottom of the barrel. Then by working the piſton, the oil will be drawn through all the parts of the pump, and the ſurplus will be driven through the tube T into the oil-veſſel G. Near the top of the piſton-rod at H there is a hole which lets ſome oil into the inſide of the rod, which gets at the collar of leathers *r r*, and keeps the wire *g g* air-tight.

When the pump is uſed for condenſation at the ſame time that it rarefies, or ſeparately, the piece containing the bent tube T muſt be removed, and fig. 41. put into its place, and fixed by its ſcrews. Fig. 41. as drawn in the plate, is intended for a double-barrelled pump. But for a ſingle barrel only one piece is uſed, repreſented by *b a a*, the double piece being cut off at the dotted line *a a*. In this piece is a female ſcrew to receive the end of a long braſs tube, to which a bladder (if ſufficient for the experiment of condenſation), or a glaſs, properly ſecured for this purpoſe, muſt be ſcrewed. Then the air which is abſtracted from the receiver on the pump-plate will be forced into the bladder or glaſs. But if the pump be double, the apparatus fig. 41. is uſed, and the long braſs tube ſcrewed on at *c*.

Fig. 41.

Fig. 42. and 43.

Fig. 42. and 43. repreſent the two gages, which will be ſufficiently explained afterwards. Fig. 42. is ſcrewed into *c b*, or into the ſcrew at the other end of *c* fig. 40. and fig. 43. into the ſcrew *a b* fig. 40.

If it be uſed as a ſingle pump, either to rarefy or condenſe, the ſcrew K, which faſtens the rack to the piſton-rod H, muſt be taken out. Then turning the winch till H is depreſſed as low as poſſible, the machine will be fitted to exhauſt as a ſingle pump; and if it be required to condenſe, the direction in N° 8. muſt be obſerved with regard to the tube T, and fig. 41.

"I took (ſays Mr Cuthbertſon) two barometer-tubes of an equal bore with that fixed to the pump. Theſe were filled with mercury four times boiled. They were then compared, and ſtood exactly at the ſame height. The mercury in one of them was boiled in it four times more, without making any change in their height; they were therefore judged very perfect. One of theſe was immerſed in the ciſtern of the pump-gage, and faſtened in a poſition parallel to it, and a ſliding ſcale of one inch was attached to it. This ſcale, when the gage is uſed, muſt have its upper edge ſet equal with the ſurface of the mercury in the boiled tube after exhauſtion, and the difference between the height of the mercury in this and in the other barometer tube may be obſerved to the $\frac{1}{100}$ of an inch; and being cloſe together, no error ariſes from their not being exactly vertical, if they are only parallel. This gage will be better underſtood by inſpecting fig. 43.

Air-pump.

"I uſed a ſecond gage, which I ſhall call a double ſyphon. See fig. 42. This was alſo prepared with the utmoſt care. I had a ſcale for meaſuring the difference between the height of the columns in the two legs. It was an inch long, and divided as the former, and kept in a truly vertical poſition by ſuſpending it from a point with a weight hung to it, as repreſented in the figure. Upon comparing theſe two gages, I always found them to indicate the ſame degree of rarefaction. I alſo uſed a pear-gage, though the moſt imperfect of all, in order to repeat the curious experiments of Mr Nairne and others."

When experiments require the utmoſt rarefying power of the pump, the receiver muſt not be placed on leather, either oiled or ſoaked in water, as is uſually done. The pump-plate and the edge of the receiver muſt be ground very flat and true, and this with very fine emery, that no roughneſs may remain. The plate of the pump muſt then be wiped very clean and very dry, and the receiver rubbed with a warm cloth till it become electrical. The receiver being now ſet on the plate, hog's lard, either alone or mixed with a little oil, which has been cleared of water by boiling, muſt be ſmeared round its outſide edge. In this condition the pump will rarefy its utmoſt, and what ſtill remains in the receiver will be permanent air. Or a little of this compoſition may be thinly ſmeared on the pump-plate; this will prevent all riſk of ſcratching it with the edge of the receiver. Leather of very uniform thickneſs, long dried before a fire, and well ſoaked in this compoſition, which muſt be cleared of all water by the firſt boiling, will anſwer very well, and is expeditious, when receivers are to be frequently ſhifted. Other leathers ſhould be at hand ſoaked in a compoſition containing a little roſin. This gives it a clammineſs which renders it impermeable to air, and is very proper at all joints of the pump, and all apparatus for pneumatic experiments. As it is impoſſible to render the pear-gage as dry as other parts of the apparatus, there will be generally ſome variation between this and the other gages.

When it is only intended to ſhow the utmoſt power of the pump, without intending to aſcertain the quality of the reſiduum, the receiver may be ſet on wet leather. If, in this condition, the air be rarefied as far as poſſible, the ſyphon and barometer gage will indicate a leſs degree of rarefaction than in the former experiments. But when the air is let in again, the pear-gage will point out a rarefaction ſome thouſands of times greater than it did before. If the true quality of permanent air after exhauſtion be required, the pear-gage will be neareſt the truth: for when the air is rarefied to a certain degree, the moiſtened leather emits an expanſible fluid, which, filling the receiver, forces out the permanent air; and the two firſt gages indicate a degree of exhauſtion which relates to the whole elaſtic matter remaining in the receiver, viz. to the expanſible fluid together with the permanent air; whereas the pear-gage points out the degree of exhauſtion, with relation

relation to the permanent air alone, which remains in the receiver; for by the preſſure of the air admitted into the receiver, the elaſtic vapour is reduced to its former bulk, which is imperceptible.

Many bodies emit this elaſtic fluid when the preſſure of the air is much diminiſhed; a piece of leather, in its ordinary damp ſtate, about an inch ſquare, or a bit of green or dry wood, will ſupply this for a great while.

When ſuch fluids have been generated in any experiments, the pump muſt be carefully cleared of them, for they remain not only in the receiver, but in the barrels and paſſages, and will again expand when the exhauſtion has been carried far.

The beſt method of clearing the pump is to take a very large receiver, and, uſing every precaution to exhauſt it as far as poſſible. Then the expanſible matter lurking in the barrels and paſſes will be diffuſed through the receiver alſo, or will be carried off along with its air. It will be as much rarer than it was before, as the aggregate capacity of the receiver barrels and paſſes is larger than that of the two laſt.

The performance of the pump may be judged of from the four following experiments.

The two gages being ſcrewed into their places, and the hole in the receiver-plate ſhut up, the pump was made to exhauſt as far as it could. The mercury in the legs of the ſyphon was only $\frac{1}{40}$ of an inch out of the level, and that in the boiled barometer-tube $\frac{1}{40}$ of an inch higher than in the one ſcrewed to the pump. A ſtandard barometer then ſtood at 30 inches, and therefore the pump rarefied the permanent air 1200 times. This is twice as much as Mr Nairne found Mr Smeaton's do in its beſt ſtate. Mr Cavallo ſeems diſpoſed to give a favourable (while we muſt ſuppoſe it a juſt) account of Haas and Hurter's pump, and it appears never to have exceeded 600 times. Mr Cuthbertſon has often found the mercury within $\frac{1}{100}$ of an inch of the level in the ſyphon-gage, indicating a rarefaction of 3000.

To one end of a glaſs tube, 2 inches diameter and 30 inches long, was fitted a braſs cap and collar of leather, through which a wire was inſerted, reaching about two inches within the tube. This was connected with the conductor of an electric machine. The other end was ground flat and ſet on the pump plate. When the gages indicated a rarefaction of 3000, the light became ſteady and uniform, of a pale colour, though a little tinged with purple; at 600 the light was of a pale duſky white; when 1200 it diſappeared in the middle of the tube, and the tube conducted ſo well that the prime conductor only gave ſparks ſo faint and ſhort as to be ſcarcely perceptible. After taking off the tube, and making it as dry as poſſible, it was again connected with the conductor, which was giving ſparks two inches long. When the air in it was rarefied ten times, the ſparks were of the ſame length. Sometimes a pencil of light darted along the tube. When the rarefaction was 20, the ſpark did not exceed an inch, and light ſtreamed the whole length of the tube. When the rarefaction was 30, the ſparks were half an inch, and the light ruſhed along the tube in great ſtreams. When the rarefaction was 100, the ſparks were about $\frac{1}{8}$ long, and the light filled the tube in an uninterrupted body. When 300, the appearances were as before. When 600, the ſparks were $\frac{1}{10}$, and the light was of a faint white colour in the middle, but tinged with purple toward the ends. When 1200, the light was hardly perceptible in the middle, and was much fainter at the ends than before, but ſtill ruddy. When 1400, which was the moſt the pump could produce, ſix inches of the middle of the tube were quite dark, and the ends free of any tinge of red, and the ſparks did not exceed $\frac{1}{40}$ of an inch.

158 The beſt improvements of the air-pump have been made in Britain.

We truſt that our readers will not be diſpleaſed with the preceding hiſtory of the air-pump. The occaſional information which it gives will be of great uſe to every perſon much engaged in pneumatic experiments, and help him in the contrivance and conſtruction of the neceſſary apparatus.

We may be indulged in one remark, that although this noble inſtrument originated in Germany, all its improvements were made in this kingdom. Both the mechanical and pneumatical principles of Mr Boyle's conſtruction were extremely different from the German, and, in reſpect of expedition and conveniency, much ſuperior. The double barrel and gage by Hawkeſbee were capital improvements, and on principle; and Mr Smeaton's method of making the piſton work in rarefied air made a complete change in the whole proceſs.

159 Utility of the air-pump.

Aided by this machine, we can make experiments eſtabliſhing and illuſtrating the gravity and elaſticity of the air, in a much more perſpicuous manner than could be done by the ſpontaneous phenomena of nature.

160 Experiments to ſhow this utility.

It allows us in the firſt place to ſhow the materiality of air in a very diſtinct manner. Bodies cannot move about in the atmoſphere without diſplacing it. This requires force; and the reſiſtance of the air always diminiſhes the velocity of bodies moving in it. A heavy body therefore has the velocity of its fall diminiſhed; and if the quantity of air diſplaced be very great, the diminution will be very conſiderable. This is the reaſon why light bodies, ſuch as feathers, fall very ſlowly. Their moving force is very ſmall, and can therefore diſplace a great quantity of air only with a very ſmall velocity. But if the ſame body be dropped *in vacuo*, when there is no air to be diſplaced, it falls with the whole velocity competent to its gravity. Fig. 44. repreſents an apparatus by which a guinea and a downy feather are dropped at the ſame inſtant, by opening the forceps which holds them by means of the ſlip-wire in the top of the receiver. If this be done after the air has been pumped out, the guinea and the feather will be obſerved to reach the bottom at the ſame inſtant.

Plate cccxxix. fig. 44.

161 Fig. 45.

Fig. 45. repreſents another apparatus for ſhowing the ſame thing. It conſiſts of two ſets of braſs vanes put in ſeparate axles, in the manner of windmill ſails. One ſet has their edges placed in the direction of their whirling motion, that is, in a plane to which the axis is perpendicular. The planes of the other ſet paſs through the axis, and they are therefore trimmed ſo as directly to front the air through which they move. Two ſprings act upon pins projecting from the axis; and their ſtrength or tenſions are ſo adjuſted, that when they are diſengaged *in vacuo*, the two ſets continue in motion equally long. If they are diſengaged in the air, the vanes which beat the air with their planes will ſtop long before thoſe which cut it edgewiſe.

162

We can now abſtract the air moſt completely from a

Air-pump. a dry veſſel, ſo as to know the preciſe weight of the air which filled it. The firſt experiment we have of this kind, done with accuracy, is that of Dr Hooke, February 10. 1664, when he found 114 pints of air to weigh 945 grains. One pint of water was $8\frac{7}{32}$ ounces. This gives for the ſpecific gravity of air $\frac{1}{830}$ very nearly.

163 The effect of air on the weight of bodies immerſed in it.

Since we are thus immerſed in a gravitating fluid, it follows, that every body preponderates only with the exceſs of its own weight above that of the air which it diſplaces; for every body loſes by this immerſion the weight of the diſplaced air. A cubic foot loſes about 521 grains in froſty weather. We ſee balloons even riſe in the air, as a piece of cork riſes in water. A maſs of water which really contains 850 pounds will load the ſcale of a balance with 849 only, and will be balanced by about $849\frac{1}{8}$ pounds of braſs. This is evinced by a very pretty experiment, repreſented in fig. 46. A ſmall beam is ſuſpended within a receiver. To one end of the beam is appended a thin glaſs or copper ball, cloſe in every part. This is balanced by a ſmall piece of lead hung on the other arm. As the air is pumped out of the receiver, the ball will gradually preponderate, and will regain its equilibrium when the air is re-admitted. Fig. 46.

164 Some naturaliſts have propoſed, and actually uſed, a large globe of light make, ſuſpended at a beam, for a barometer. If its capacity be a cubic foot, $1\frac{7}{10}$ grains will indicate the ſame change that is indicated by $\frac{1}{10}$ of an inch of an ordinary barometer. But a veſſel of this ſize will load a balance too much to leave it ſufficiently ſenſible to ſmall changes of denſity. Beſides, it is affected by heat and cold, and would require a very troubleſome equation to correct their effects.

165 It may perhaps be worth while to attend to this in buying and ſelling precious commodities; ſuch as pearls, diamonds, ſilk, and ſome drugs. As they are generally ſold by braſs or leaden weights, the buyer will have ſome advantage when the air is heavy and the barometer high. On the other hand, he will have the advantage in buying gold and mercury when the air is light. It is needleſs to confine this obſervation to precious commodities, for the advantage is the ſame in all in proportion to their levity.

166 There is a caſe in which this obſervation is of conſequence to the philoſopher: we mean the meaſuring of time by pendulums. As the accelerating force on a pendulum is not its whole weight, but the exceſs of its weight over that of the diſplaced air, it follows that a pendulum will vibrate more ſlowly in the air than *in vacuo*. A pendulum compoſed of lead, iron, and braſs, may be about 8400 times heavier than the air which it diſplaces when the barometer is at 30 inches and the thermometer at 32°, and the accelerating force will be diminiſhed about $\frac{1}{16800}$. This will cauſe a ſecond pendulum to make about five vibrations leſs in a day than it would do *in vacuo*. In order therefore to deduce the accelerative power of gravity from the length of a pendulum vibrating in the air, we muſt make an allowance of 0″.17, or $\frac{17}{100}$ of a ſecond, per day for every inch that the barometer ſtands lower than 30 inches. But we muſt alſo note the temperature of the air; becauſe when the air is warm it is leſs denſe when ſupporting by its elaſticity the ſame weight of atmoſphere, and we muſt know how much its denſity is diminiſhed by an increaſe of temperature. The correction is ſtill more complicated; for the change of denſity affects the reſiſtance of the air, and this affects the time of the vibration, and this by a law that is not yet well aſcertained. As far as we can determine from any experiments that have been made, it appears that the change ariſing from the altered reſiſtance takes off about $\frac{2}{5}$ of the change produced by the altered denſity, and that a ſecond pendulum makes but three vibrations a-day more *in vacuo* than in the open air. This is a very unexpected reſult: but it muſt be owned that the experiments have neither been numerous nor very nicely made.

The air-pump alſo allows us to ſhow the effects of the air's preſſure in a great number of amuſing and inſtructive phenomena.

167 Experiments to ſhow the effects of the air's preſſure.

When the air is abſtracted from the receiver, it is ſtrongly preſſed to the pump-plate by the incumbent atmoſphere, and it ſupports this great preſſure in conſequence of its circular form. Being equally compreſſed on all ſides, there is no place where it ſhould give way rather than another; but if it be thin, and not very round, which is ſometimes the caſe, it will be cruſhed to pieces. If we take a ſquare thin phial, and apply an exhauſting ſyringe to its mouth, it will not fail being cruſhed.

As the operation of pumping is ſomething like ſucking, many of theſe phenomena are in common diſcourſe aſcribed to ſuction, a word much abuſed; and this abuſe miſleads the mind exceedingly in its contemplation of natural phenomena. Nothing is more uſual than to ſpeak of the ſuction of a ſyringe, the ſuction and draught of a chimney, &c. The following experiment puts the true cauſe of the ſtrong adheſion of the receiver beyond a doubt.

Place a ſmall receiver or cupping-glaſs on the pump-plate without covering the central hole, as repreſented in fig. 47. and cover it with a larger receiver. Exhauſt the air from it; then admit it as ſuddenly as poſſible. Fig. 47. The outer receiver, which after the rarefaction adhered ſtrongly to the plate, is now looſe, and the cupping-glaſs will be found ſticking faſt to it. While the rarefaction was going on, the air in the ſmall receiver alſo expanded, eſcaped from it, and was abſtracted by the pump. When the external air was ſuddenly admitted, it preſſed on the ſmall receiver, and forced it down to the plate, and thus ſhut up all entry. The ſmall receiver muſt now adhere; and there can be no ſuction, for the pipe of the pump was on the outſide of the cupping-glaſs.

This experiment ſometimes does not ſucceed, becauſe the air ſometimes finds a paſſage under the brim of the cupping-glaſs. But if the cupping-glaſs be preſſed down by the hand on the greaſy leather or plate, every thing will be made ſmooth, and the glaſs will be ſo little raiſed by the expanſion of its air during the pumping, that it will inſtantly clap cloſe when the air is re-admitted.

In like manner, if a thin ſquare phial be furniſhed with a valve, opening from within, but ſhutting when preſſed from without, and if this phial be put under a receiver, and the air be abſtracted from the receiver, the air in the phial will expand during the rarefaction, will eſcape through the valve, and be at laſt in a very rarefied ſtate within 168

Air-pump. within the phial. If the air be now admitted into the receiver, it will press on the flat sides of the included
Fig. 48. phial and crush it to pieces. See fig. 48.

169 If a piece of wet ox-bladder be laid over the top of a receiver whose orifice is about four inches wide, and the air be exhausted from within it, the incumbent atmosphere will press down the bladder into a hollow form, and then burst it inward with a prodigious noise.
Fig. 49. See fig. 49. Or if a piece of thin flat glass be laid over the receiver, with an oiled leather between them to make the juncture air-tight, the glass will be broken downwards. This must be done with caution, because the pieces of glass sometimes fly about with great force.

170 If there be formed two hemispherical cups of brass, with very flat thick brims, and one of them be fitted with a neck and stopcock, as represented by fig. 50. the
Fig. 50. air may be abstracted from them by screwing the neck into the hole in the pump-plate. To prevent the insinuation of air, a ring of oiled leather may be put between the rims. Now unscrew the sphere from the pump, and fix hooks to each, and suspend them from a strong nail, and hang a scale to the lowest. It will require a considerable weight to separate them; namely, about 15 pounds for every square inch of the great circle of the sphere. If this be four inches diameter, it will require near 190 pounds. This pretty experiment was first made by Otto Guericke, and on a very great scale. His sphere was of a large size, and when exhausted the hemispheres could not be drawn asunder by 20 horses. It was exhibited, along with many others equally curious and magnificent, to the emperor of Germany and his court, at the breaking up of the diet of Ratisbon in 1654.

171 If the loaded syringe mentioned in N° 16. be suspended by its piston from the hook in the top plate of the receiver, as in fig. 51. and the air be abstracted by the
Fig. 51. pump, the syringe will gradually descend (because the elasticity of the air, which formerly balanced the pressure of the atmosphere, is now diminished by its expansion, and is therefore no longer able to press the syringe to the piston), and it will at last drop off. If the air be admitted before this happens, the syringe will immediately rise again.

172 Screw a short brass pipe into the neck of a transporter, N° 107. on which is set a tall receiver, and immerse it into a cistern of water. On opening the cock the pressure of the air on the surface of the water in the cistern will force it up through the pipe, and cause it to spout into the receiver with a strong jet, because there is no air within to balance by its elasticity the pressure of the
Fig. 52. atmosphere. See fig. 52.

173 By means of this pressure the gage of an air-pump acts. It is in the same way that the gage of the air-pump performs its office. The pressure of the atmosphere raises the mercury in the gage till the weight of the mercury, together with the remaining elasticity of the air in the receiver, are in equilibrio with the whole pressure of the atmosphere: therefore the height and weight of the mercury in the gage is the excess of the weight of the atmosphere above the elasticity of the included air; and the deficiency of this height from that of the mercury in the Toricellian tube is the measure of this remaining elasticity.

174 If a Toricellian tube be put under a tall receiver, as
Fig. 53. shown in fig. 53. and the air be exhausted, the mercury in the tube will descend while that in the gage will rise; and the sum of their heights will always be the same, that is, equal to the height in an ordinary barometer. Air-pump.
The height of the mercury in the receiver is the effect and measure of the remaining elasticity of the included air, and the height in the pump-gage is the unbalanced pressure of the atmosphere. This is a very instructive experiment, perfectly similar to Mr Auzout's, mentioned in N° 34. and completely establishes and illustrates the whole doctrine of atmospheric pressure.

We get a similar illustration and confirmation (if such a thing be now needed) of the cause of the rise of water in pumps, by screwing a syringe into the top plate of a receiver, which syringe has a short glass pipe plunging into a small cup of water. See fig. 54. When the piston-rod is drawn up, the water rises in the glass pipe, as in any other pump, of which this is a miniature representation. But if the air has been previously exhausted from the receiver, there is nothing to press on the water in the little jar; and it will not rise in the glass pipe though the piston of the syringe be drawn to the top. 175 Water rises in pumps, Fig. 54.

Analogous to the rise of water in pumps is its rise and motion in syphons. Suppose a pipe ABCD, fig. 55. bent at right angles at B and C, and having its two ends immersed in the cisterns of water A and D. Let the leg CD be longer than the leg BA, and let the whole be full of water. The water is pressed upwards at A with a force equal to the weight of the column of air E A reaching to the top of the atmosphere; but it is pressed downwards by the weight of the column of water B A. The water at E is pressed downwards by the weight of the column CD, and upwards by the weight of the column of air FD reaching to the top of the atmosphere. The two columns of air differ very little in their weight, and may without any sensible error be considered as equal. Therefore there is a superiority of pressure downwards at D, and the water will flow out there. The pressure of the air will raise the water in the leg AB, and thus the stream will be kept up till the vessel A is emptied as low as the orifice of the leg BA, provided the height of AB is not greater than what the pressure of the atmosphere can balance, that is, does not exceed 32 or 33 feet for water, 30 inches for mercury, &c. 176 and moves in syphons. Fig. 55.

A syphon then will always run from that vessel whose surface is highest; the form of the pipe is indifferent, because the hydrostatical pressures depend on the vertical height only. It must be filled with water by some other contrivance, such as a funnel, or a pump applied a-top; and the funnel must be stopped up, otherwise the air would get in, and the water would fall in both legs.

If the syphon have equal legs, as in fig. 56. and be turned up at the ends, it will remain full of water, and be ready for use. It need only be dipped into any vessel of water, and the water will then flow out at the other end of the syphon. This is called the *Wirtemberg syphon*, and is represented in fig. 56. Syphons will afterwards be considered more minutely under the title of *PNEUMATICAL Engines*, at the end of this article. 177 Fig. 56.

What is called the *syphon fountain*, constructed on this principle, is shown in fig. 57. where AB is a tall receiver, standing in a wide bason DE, which is supported on the pedestal H by the hollow pillar FG. In the centre of the receiver is a jet pipe C, and in the top a ground stopper A. Near the base of the pillar is a cock N, and in the pedestal is another cock O. 178 The syphon fountain. Fig. 57.

Fill

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Fill the bason DE with water within half an inch of the brim. Then pour in water at the top of the receiver (the cock N being shut) till it is about half full, and then put in the stopper. A little water will run out into the vessel DE. But before it runs over, open the cock N, and the water will run into the cistern H; and by the time that the pipe C appears above water, a jet will rise from it, and continue as long as water is supplied from the bason DE. The passage into the base cistern may be so tempered by the cock N that the water within the receiver shall keep at the same height, and what runs into the base may be received from the cock O into another vessel, and returned into DE, to keep up the stream.

179 Manner of its construction and operation. Fig. 58.

This pretty philosophical toy may be constructed in the following manner. BB, fig. 58. is the ferril or cap into which the receiver is cemented. From its centre descends the jet pipe C*a*, sloping outwards, to give room for the discharging pipe *b d* of larger diameter, whose lower extremity *d* fits tightly into the top of the hollow pillar FG.

Fig. 57.

The operation of the toy is easily understood. Suppose the distance from C to H (fig. 57.) three feet, which is about $\frac{1}{11}$ of the height at which the atmosphere would support a column of water. The water poured into AB would descend through FG (the hole A being shut) till the air has expanded $\frac{1}{10}$, and then it would stop. If the pipe C*a* be now opened, the pressure of the air on the surface of the water in the cistern DE will cause it to spout through C to the height of three feet nearly, and the water will continue to descend through the pipe FG. By tempering the cock N so as to allow the water to pass through it as fast as it is supplied by the jet, the amusement may be continued a long time. It will stop at last, however; because, as the jet is made into rarefied air, a little air will be extricated from the water, which will gradually accumulate in the receiver, and diminish its rarefaction, which is the moving cause of the jet. This indeed is an inconvenience felt in every employment of syphons, so much the more remarkably as their top is higher than the surface of the water in the cistern of supply.

180 Syphons are often used thus. Fig. 59.

Cases of this employment of a syphon are not unfrequent. When water collected at A (fig. 59.) is to be conducted in a pipe to C, situated in a lower part of the country, it sometimes happens, as between Lochend and Leith, that the intervening ground is higher than the fountain-head as at B. A forcing pump is erected at A, and the water forced along the pipe. Once it runs out at C, the pump may be removed, and the water will continue to run on the syphon principle, provided BD do not exceed 33 feet. But the water in that part of the conduit which is above the horizontal plane AD, is in the same state as in a receiver of rarefied air, and gives out some of the air which is chemically united with it. This gradually accumulates in the elevated part of the conduit, and at last choaks it entirely. When this happens, the forcing pump must again be worked. Although the elevation in the Leith conduit is only about eight or ten feet, it will seldom run for 12 hours. N. B. This air cannot be discharged by the usual air-cocks; for if there were an opening at B, the air would rush in, and immediately stop the motion.

181 The air-pump discovers the combination of air with water,

This combination of air with water is very distinctly seen by means of the air-pump. If a small glass containing cold water, fresh drawn from the spring, be exposed, as in fig. 60. under the receiver, and the air rarefied, small bubbles will be observed to form on the inner surface of the glass, or on the surface of any body immersed in it, which will increase in size, and then detach themselves from the glass and reach the top; as the rarefaction advances, the whole water begins to show very minute air-bubbles rising to the top; and this appearance will continue for a very long time, till it be completely disengaged. Warming the water will occasion a still farther separation of air, and a boiling heat will separate all that can be disengaged. The reason assigned for these air-bubbles first appearing on the surface of the glass, &c. is, that air is attracted by bodies, and adheres to their surface. This may be so. But it is more probably owing to the attraction of the water for the glass, which causes it to quit the air which it held in solution, in the same manner as we see it happen when it is mixed with spirits-of-wine, with vitriolic acid, &c. or when salts or sugar are dissolved in it. For if we pour out the water which has been purged of air by boiling *in vacuo*, and fill the glass with fresh water, we shall observe the same thing, although a film of the purified water was left adhering to the glass. In this case there can be no air adhering to the glass.

Elasticity, &c. Plate ccccxxx. fig. 60.

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Water thus purged of air by boiling (or even without boiling) *in vacuo*, will again absorb air when exposed to the atmosphere. The best demonstration of this is to fill with this water a phial, leaving about the size of a pea not filled. Immerse this in a vessel of water, with the mouth undermost, by which means the air-bubble will mount up to the bottom of the phial. After some days standing in this condition, the air-bubble will be completely absorbed, and the vessel quite filled with water.

The air in this state of chemical solution has lost its elasticity, for the water is not more compressible than common water. It is also found that water brought up from a great depth under ground contains much more air than water at the surface. Indeed fountain waters differ exceedingly in this respect. The water which now comes into the city of Edinburgh by pipes contains so much as to throw it into a considerable ebullition *in vacuo*. Other liquors contain much greater quantities of elastic fluids in this loosely combined state. A glass of beer treated in the same way will be almost wholly converted into froth by the escape of its fixed air, and will have lost entirely the prickling smartness which is so agreeable, and become quite vapid.

183 and illustrates the air's elasticity and expansibility.

The air-pump gives us, in the next place, a great variety of experiments illustrative of the air's elasticity and expansibility. The very operation of exhaustion, as it is called, is an instance of its great, and hitherto unlimited, expansibility. But this is not palpably exhibited to view. The following experiments show it most distinctly.

184 Experiments showing these properties.

1st, Put a flaccid bladder, of which the neck is firmly tied with a thread, under a receiver, and work the pump. The bladder will gradually swell, and will even be fully distended. Upon readmitting the air into the receiver, the bladder gradually collapses again into its former dimensions: while the bladder is flaccid, the air within it is of the same density and elasticity with the surrounding air, and its elasticity balances the pressure of the atmosphere. When part of the air of

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of the receiver is abſtracted, the remainder expands ſo as ſtill to fill the receiver: but by expanding, its elaſticity is plainly diminiſhed; for we ſee by the fact, that the elaſticity of the air of the receiver no longer balances the elaſticity of that in the bladder, as it no longer keeps it in its dimenſions. The air in the bladder expands alſo: it expands till its diminiſhed elaſticity is again in equilibrio with the diminiſhed elaſticity of the air in the receiver; that is, till its denſity is the ſame. When all the wrinkles of the bladder have diſappeared, its air can expand no more, although we continue to diminiſh the elaſticity of the air of the receiver by further rarefaction. The bladder now tends to burſt; and if it be pierced by a point or knife faſtened to the ſlip-wire, the air will ruſh out, and the mercury deſcend rapidly in the gage.

185 If a phial or tube be partly filled with water, and immerſed in a veſſel of water with the mouth downwards, the air will occupy the upper part of the phial. If this apparatus be put under a receiver, and the air be abſtracted, the air in the phial will gradually expand, allowing the water to run out by its weight till the ſurface of the water be on a level within and without. When this is the caſe, we muſt grant that the denſity and elaſticity of the air in the phial is the ſame with that in the receiver. When we work the pump again, we ſhall obſerve the air in the phial expand ſtill more, and come out of the water in bubbles. Continuing the operation, we ſhall ſee the air continually eſcaping from the phial: when this is over, it ſhows that the pump can rarefy no more. If we now admit the air into the receiver, we ſhall ſee the water riſe into the phial, and at laſt almoſt completely fill it, leaving only a very ſmall bubble of air at top. This bubble had expanded ſo as to fill the whole phial. See this repreſented in fig. 61. Fig. 61.

186 Every one muſt have obſerved a cavity at the big end of an egg between the ſhell and the white. The white and yolk are contained in a thin membrane or bladder which adheres looſely to the ſhell, but is detached from it at that part; and this cavity increaſes by keeping the egg in a dry place. One may form a judgement of its ſize, and therefore of the freſhneſs of the egg, by touching it with the tongue; for the ſhell, where it is not in contact with the contents, will preſently feel warm, being quickly heated by the tongue, while the reſt of the egg will feel cold.

If a hole be made in the oppoſite end of the egg, and it be ſet on a little tripod, and put under a receiver, the expanſion of the air in the cavity of the egg will force the contents through the hole till the egg be quite emptied: or, if nearly one half of the egg be taken away at the other end, and the white and yolk taken out, and the ſhell be put under a receiver, and the air abſtracted, the air in the cavity of the egg will expand, gradually detaching the membrane from the ſhell, till it cauſes it to ſwell out, and gives the whole the appearance of an entire egg. In like manner ſhrivelled apples and other fruits will ſwell in vacuo by the expanſion of the air confined in their cavities.

187 If a piece of wood, a twig with green leaves, charcoal, plaſter of Paris, &c. be kept under water in vacuo, a prodigious quantity of air will be extracted; and if we readmit the air into the receiver, it will force the water into the pores of the body. In this caſe the body will not ſwim in water as it did before, ſhowing that the vegetable fibres are ſpecifically heavier than water. It is found, however, that the air contained in the pith and bark, ſuch as cork, is not all extricated in this way; and that much of it is contained in veſicles which have no outlet: being ſecreted into them in the proceſs of vegetation, as it is ſecreted into the air-bladder of fiſhes, where it is generally found in a pretty compreſſed ſtate, conſiderably denſer than the ſurrounding air. The air-bladder of a fiſh is ſurrounded by circular and longitudinal muſcles, by which the fiſh can compreſs the air ſtill further; and, by ceaſing to act with them, allow it to ſwell out again. It is in this manner that the fiſh can ſuit its ſpecific gravity to its ſituation in the water, ſo as to have no tendency either to riſe or ſink: but if the fiſh be put into the receiver of an air-pump, the rarefaction of the air obliges the fiſh to act more ſtrongly with theſe contracting muſcles, in order to adjuſt its ſpecific gravity; and if too much air has been abſtracted from the receiver, the fiſh is no longer able to keep its air-bladder in the proper degree of compreſſion. It becomes therefore too buoyant, and comes to the top of the water, and is obliged to ſtruggle with its tail and fins in order to get down; frequently in vain. The air-bladder ſometimes burſts, and the fiſh goes to the bottom, and can no longer keep above without the continual action of its tail and fins. When fiſhes die, they commonly float at top, their contractive action being now at an end. All this may be illuſtrated (but very imperfectly) by a ſmall half blown bladder, to which is appended a bit of lead, juſt ſo heavy as to make it ſink in water: when this is put under a receiver, and the air abſtracted, the bubble will riſe to the top; and, by nicely adjuſting the rarefaction, it may be kept at any height. See fig. 62. Fig. 62.

188 The playthings called *Carteſian devils* are ſimilar to this: they are hollow glaſs figures, having a ſmall aperture in the lower part of the figures, as at the point of the foot; their weight is adjuſted ſo that they ſwim upright in water. When put into a tall jar filled to the top, and having a piece of leather tied over it, they will ſink in the water, by preſſing on the leather with the ball of the hand: this, by compreſſing the water, forces ſome of it to enter into the figure and makes it heavier than the water; for which reaſon it ſinks, but riſes again on removing the preſſure of the hand. See figs. 63 and 64. Figs. 63. and 64.

If a half blown ox-bladder be put into a box, and great weights laid on it, and the whole be put under a receiver, and the air abſtracted; the air will, by expanding, lift up the weights, though above an hundred pounds. See fig. 65. Fig. 65.

189 Compreſſibility and expanſibility are in no ſtate of the air very diſſimilar.

By ſuch experiments the great expanſibility of the air is abundantly illuſtrated, as its compreſſibility was formerly by means of the condenſing ſyringe. We now ſee that the two ſets of experiments form an uninterrupted chain; and that there is no particular ſtate of the air's denſity where the compreſſibility and expanſibility are remarkably diſſimilar. Air in its ordinary ſtate expands; becauſe its ordinary ſtate is a ſtate of compreſſion by the weight of the atmoſphere: and if there were a pit about 33 miles deep, the air at the bottom would probably be as denſe as water; and if it were 50 miles deep, it would be as denſe as gold, if it did not become a liquid before this depth: nay, if a bottle with its mouth undermoſt were immerſed ſix miles under water, it would probably be as denſe as water; we ſay probably,

probably, for this depends on the nature of its compreſſibility; that is, on the relation which ſubſiſts between the compreſſion and the force which produces it.

190 Relation between compreſſion and the force producing it.

This is the circumſtance of its conſtitution, which we now proceed to examine; and it is evidently a very important circumſtance. We have long ago obſerved, that the great compreſſibility and permanent fluidity of air, obſerved in a vaſt variety of phenomena, is totally inexplicable, on the ſuppoſition that the particles of air are like ſo many balls of ſponge or ſo many foot-balls. Give to thoſe what compreſſibility you pleaſe, common air could no more be fluid than a maſs of clay; it could no more be fluid than a maſs of ſuch balls preſſed into a box. It can be demonſtrated (and indeed hardly needs a demonſtration), that before a parcel of ſuch balls, juſt touching each other, can be ſqueezed into half their preſent dimenſions, their globular ſhape will be entirely gone, and each will have become a perfect cube, touching ſix other cubes with its whole ſurface; and theſe cubes will be ſtrongly compreſſed together, ſo that motion could never be performed through among them by any ſolid body without a very great force. Whereas we know that in this ſtate air is juſt as permeable to every body as the common air that we breathe. There is no way in which we can repreſent this fluidity to our imagination, but by conceiving air to conſiſt of particles, not only diſcrete, but diſtant from each other, and actuated by repulſive forces, or ſomething analogous to them. It is an idle ſubterfuge, to which ſome naturaliſts have recourſe, ſaying, that they are kept aſunder by an intervening ether, or elaſtic fluid of any other name. This is only removing the difficulty a ſtep farther off: for the elaſticity of this fluid requires the ſame explanation; and therefore it is neceſſary, in obedience to the rules of juſt reaſoning, to begin the inquiry here; that is, to determine from the phenomena what is the analogy between the diſtances of the particles and the repulſive forces exerted at theſe diſtances, proceeding in the ſame way as in the examination of planetary gravitation. We ſhall learn the analogy by attending to the analogy between the compreſſing force and the denſity.

191 Denſity explained as applied to air.

For the denſity depends on the diſtance between the particles; the nearer they are to each other, the denſer is the air. Suppoſe a ſquare pipe one inch wide and eight inches long, ſhut at one end, and filled with common air; then ſuppoſe a plug ſo nicely fitted to this pipe that no air can paſs by its ſides; ſuppoſe this piſton thruſt down to within an inch of the bottom: it is evident that the air which formerly filled the whole pipe now occupies the ſpace of one cubic inch, which contains the ſame number of particles as were formerly diffuſed over eight cubic inches.

The condenſation would have been the ſame if the air which fills a cube whoſe ſide is two inches had been ſqueezed into a cube of one inch, for the cube of two inches alſo contains eight inches. Now, in this caſe it is evident that the diſtance between the particles would be reduced to its half in every direction. In like manner, if a cube whoſe ſide is three inches, and which therefore contains 27 inches, be ſqueezed into one inch, the diſtance of the particles will be one-third of what it was: in general the diſtance of the particles will be as the cube-root of the ſpace into which they are compreſſed. If the ſpace be $\frac{1}{8}$, $\frac{1}{27}$, $\frac{1}{64}$, $\frac{1}{125}$, &c. of its former dimenſions, the diſtance of the particles will be $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, &c. Now the term *denſity*, in its ſtrict ſenſe, expreſſes the vicinity of the particles; *denſi arbores* are trees growing near each other. The meaſure of this vicinity therefore is the true meaſure of the denſity; and when 27 inches of air are compreſſed into one, we ſhould ſay that it is three times as denſe; but we ſay, that it is 27 times denſer.

192 Farther explanation

Denſity is therefore uſed in a ſenſe different from its ſtricteſt acceptation: it expreſſes the comparative number of equidiſtant particles contained in the ſame bulk. This is alſo abundantly preciſe, when we compare bodies of the ſame kind, differing in denſity only; but we alſo ſay, that gold is 19 times denſer than water, becauſe the ſame bulk of it is 19 times heavier. This aſſertion proceeds on the aſſumption, or the fact, that every ultimate atom of terreſtrial matter is equally heavy: a particle of gold may contain more or fewer atoms of matter than a particle of water. In ſuch a caſe, therefore, the term denſity has little or no reference to the vicinity of the particles; and is only a term of compariſon of other qualities or accidents.

But when we ſpeak of the reſpective denſities of the ſame ſubſtance in its different ſtates of compreſſion, the word *denſity* is ſtrictly connected with vicinity of particles, and we may ſafely take either of the meaſures. We ſhall abide by the common acceptation, and call that air eight times as denſe which has eight times as many particles in the ſame bulk, although the particles are only twice as near to each other.

193 The analogy between the compreſſing force and the diſtance of the particles, &c.

Thus then we ſee, that by obſerving the analogy between the compreſſing force and the denſity, we ſhall diſcover the analogy between the compreſſing force and the diſtance of the particles. Now the force which is neceſſary for compreſſing two particles of air to a certain vicinity is a proper meaſure of the elaſticity of the particles correſponding to that vicinity or diſtance; for it balances it, and forces which balance muſt be eſteemed equal. Elaſticity is a diſtinctive name for that corpuſcular force which keeps the particles at that diſtance: therefore obſervations made on the analogy between the compreſſing force and the denſity of air will give us the law of its corpuſcular force, in the ſame way that obſervations on the ſimultaneous deflections of the planets towards the ſun give us the law of celeſtial gravitation.

194

But the ſenſible compreſſing forces which we are able to apply is at once exerted on unknown thouſands of particles, while it is the law of action of a ſingle particle that we want to diſcover. We muſt therefore know the *proportion* of the numbers of particles on which the compreſſing force is exerted. It is eaſy to ſee, that ſince the diſtance of the particles is as the cube root of the denſity inverſely, the number of particles in phyſical contact with the compreſſing ſurface muſt be as the ſquare of this root. Thus when a cube of 8 inches is compreſſed into one inch, and the particles are twice as near each other as they were before, there muſt be four times the number of particles in contact with each of the ſides of this cubical inch; or, when we have puſhed down the ſquare piſton of the pipe ſpoken of above to within an inch of the bottom, there will be four times the number of particles *immediately* contiguous to the piſton, and reſiſting the compreſſion; and in order to obtain the force really exerted on one particle, and the elaſticity of that particle, we muſt divide the whole compreſſing

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pressing force by 4. In like manner, if we have compressed air into $\frac{1}{27}$ of its former bulk, and brought the particles to $\frac{1}{3}$ of their former distance, we must divide the compressing force by 9. In general if d express the density, $\frac{1}{\sqrt[3]{d}}$ will express the distance x of the particles; $\sqrt[3]{d}$, or $d^{\frac{1}{3}}$, will express the vicinity or real density; and $d^{\frac{2}{3}}$ will express the number of particles acting on the compressing surface: and if f express the accumulated external compressing force, $\frac{f}{d^{\frac{2}{3}}}$ will express the force acting on one particle; and therefore the elasticity of that particle corresponding to the distance x.

195 Experiments establishing the law of compression.

WE may now proceed to consider the experiments by which the law of compression is to be established.

The first experiments to this purpose were those made by Mr Boyle, published in 1661 in his *Defensio Doctrinæ de Aeris Elatere contra Linum*, and exhibited before the Royal Society the year before. Mariotte made experiments of the same kind, which were published in 1676 in his *Essai sur la Nature de l'Air* and *Traité des Mouvemens des Eaux*. The most copious experiments are those by Sulzer (*Mem. Berlin.* ix.), those by Fontana (*Opusc. Physico-Math.*), and those by Sir George Shuckburgh and Gen. Roy.

196 Compressibility of air not rarer than the atmosphere at the earth's surface. Fig. 66.

In order to examine the compressibility of air that is not rarer than the atmosphere at the surface of the earth, we employ a bent tube or syphon ABCD (fig. 66.), hermetically sealed at A and open at D. The short leg AB must be very accurately divided in the proportion of its solid contents, and fitted with a scale whose units denote equal increments, not of length, but of capacity. There are various ways of doing this; but it requires the most scrupulous attention, and without this the experiments are of no value. In particular, the arched form at A must be noticed. A small quantity of mercury must then be poured into the tube, and passed backwards and forwards till it stands (the tube being held in a vertical position) on a level at B and C. Then we are certain that the included air is of the same density with that of the contiguous atmosphere. Mercury is now poured into the leg DC, which will fill it, suppose to G, and will compress the air into a smaller space AE. Draw the horizontal line EF: the new bulk of the compressed air is evidently AE, measured by the adjacent scale, and the addition made to the compressing force of the atmosphere is the weight of the column GF. Produce GF downwards to H, till FH is equal to the height shown by a Toricellian tube filled with the *same mercury*; then the whole compressing force is HG. This is evidently the measure of the elasticity of the compressed air in AE, for it balances it. Now pour in more mercury, and let it rise to g, compressing the air into Ae. Draw the horizontal line ef, and make fh equal to FH; then Ae will be the new bulk of the compressed air, $\frac{AB}{Ae}$ will be its new density, and hg will be the measure of the new elasticity. This operation may be extended as far as we please, by lengthening the tube CD, and taking care that it be strong enough to resist the great pressure. Great care must be taken to keep the whole in a constant temperature, because the elasticity of air is greatly affected by heat, and the change by any increase of temperature is different according to its density or compression.

Compressibility, &c.

197 Experiments of Boyle, &c. neither nicely made nor extended to very great compressions.

The experiments of Boyle, Mariotte, Amontons, and others, were not extended to very great compressions, the density of the air not having been quadrupled in any of them; nor do they seem to have been made with very great nicety. It may be collected from them in general, that the elasticity of the air is very nearly proportioned to its density; and accordingly this law was almost immediately acquiesced in, and was called the *Boylean law*: it is accordingly assumed by almost all writers on the subject as exact. Of late years, however, there occurred questions in which it was of importance that this point should be more scrupulously settled, and the former experiments were repeated and extended. Sulzer and Fontana have carried them farther than any other. Sulzer compressed air into one-eighth of its former dimensions.

198 Varieties, &c. in these experiments.

Considerable varieties and irregularities are to be observed in these experiments. It is extremely difficult to preserve the temperature of the apparatus, particularly of the leg AB, which is most handled. A great quantity of mercury must be employed; and it does not appear that philosophers have been careful to have it precisely similar to that in the barometer, which gives us the unit of compressing force and of elasticity. The mercury in the barometer should be pure and boiled. If the mercury in the syphon is adulterated with bismuth and tin, which it commonly is to a considerable degree, the compressing force, and consequently the elasticity, will appear greater than the truth. If the barometer has not been nicely fitted, it will be lower than it should be, and the compressing force will appear too great, because the unit is too small; and this error will be most remarkable in the smaller compressions.

199 Heterogeneous nature of the air the greatest source of error.

The greatest source of error and irregularity in the experiments is the very heterogeneous nature of the air itself. Air is a solvent of all fluids, all vapours, and perhaps of many solid bodies. It is highly improbable that the different compounds shall have the same elasticity, or even the same law of elasticity: and it is well known, that air, loaded with water or other volatile bodies, is much more expansible by heat than pure air; nay, it would appear from many experiments, that certain determinate changes both of density and of temperature, cause air to let go the vapours which it holds in solution. Cold causes it to precipitate water, as appears in dew; so does rarefaction, as is seen in the receiver of an air-pump.

200 The air's elasticity does not increase so fast as its density.

In general, it appears that the elasticity of air does not increase quite so fast as its density. This will be best seen by the following tables, calculated from the experiments of Mr Sulzer. The column E in each set of experiments expresses the length of the column GH, the unit being FH, while the column D expresses $\frac{AB}{AE}$.

1st

Experiments on Air.

1st Set.		2d Set.		3d Set.	
D	E	D	E	D	E
1.000	1.000	1.000	1.000	1.000	1.000
1.100	1.093	1.236	1.224	1.091	1.076
1.222	1.211	1.294	1.288	1.200	1.183
1.375	1.284	1.375	1.332	1.333	1.303
1.571	1.559	1.466	1.417	1.500	1.472
1.692	1.669	1.571	1.515	1.714	1.659
1.833	1.796	1.692	1.647		
2.000	1.958	2.000	1.964	2.000	1.900
2.288	2.130				
2.444	2.375	2.444	2.392	2.400	2.241
3.143	2.936	3.143	3.078	3.000	2.793
3.666	3.391	3.666	3.575		
4.000	3.706			4.000	3.631
4.444	4.035	4.444	4.320		
4.888	4.438				
5.500	4.922	5.500	5.096		
5.882	5.522			6.000	5.297
		7.333	6.694		
				8.000	6.835

There appears in these experiments sufficient grounds
201 for calling in question the Boylean law; and the writer of this article thought it incumbent on him to repeat them with some precautions, which probably had not been attended to by Mr Sulzer. He was particularly anxious to have the air as free as possible from moisture. For this purpose, having detached the short leg of the syphon, which was 34 inches long, he boiled mercury in it, and filled it with mercury boiling hot. He took a tinplate vessel of sufficient capacity, and put into it a quantity of powdered quicklime just taken from the kiln; and having closed the mouth, he agitated the lime through the air in the vessel, and allowed it to remain there all night. He then emptied the mercury out of the syphon into this vessel, keeping the open end far within it. By this means the short leg of the syphon was filled with very dry air. The other part was now joined, and boiled mercury put into the bend of the syphon; and the experiment was then prosecuted with mercury which had been recently boiled, and was the same with which the barometer had been carefully filled.

202 The results of the experiments are expressed in the following table.

Dry Air.		Moist Air.		Damp Air.	
D	E	D	E	D	E
1.000	1.000	1.000	1.000	1.000	1.000
2.000	1.957	2.000	1.920	2.000	1.909
3.000	2.848	3.000	2.839	3.000	2.845
4.000	3.737	4.000	3.726	4.000	3.718
5.500	4.930	5.500	5.000	5.500	5.104
6.000	5.342	6.000	5.452	6.000	5.463
7.620	6.490	7.620	6.775	7.620	6.812

Here it appears again in the clearest manner that the elasticities do not increase as fast as the densities, and the differences are even greater than in Mr Sulzer's experiments.

Elasticity.

The second table contains the results of experiments made on very damp air in a warm summer's morning. 203 In these it appears that the elasticities are almost precisely proportional to the densities + a small constant quantity, nearly 0.11, deviating from this rule chiefly between the densities 1 and 1.5, within which limits we have very nearly $D = E^{1.0017}$. As this air is nearer to the constitution of atmospheric air than the former, this rule may be safely followed in cases where atmospheric air is concerned, as in measuring the depths of pits by the barometer.

The third table shows the compression and elasticity 204 of air strongly impregnated with the vapours of camphire. Here the Boylean law appears pretty exact, or rather the elasticity seems to increase a little faster than the density.

Dr Hooke examined the compression of air by im- 205 mersing a bottle to great depths in the sea, and weighing the water which got into it without any escape of air. But this method was liable to great uncertainty, on account of the unknown temperature of the sea at great depths.

Hitherto we have considered only such air as is not 206 rarer than what we breathe; we must take a very different method for examining the elasticity of rarefied air.

Mode of examining the elasticity of rarefied air.

Let gh (fig. 67.) be a long tube, formed a-top into a cup, and of sufficient diameter to receive another smaller tube af, open at first at both ends. Let the outer tube and cup be filled with mercury, which will rise in the inner tube to the same level. Let af now be stopped at a. It contains air of the same density and elasticity with the adjoining atmosphere. Note exactly the space ab which it occupies. Draw it up into the position of fig. 68. and let the mercury stand in it at the height de, while ce is the height of the mercury in the barometer. It is evident that the column de is in equilibrio between the pressure of the atmosphere and the elasticity of the air included in the space ad. And since the weight of ce would be in equilibrio with the whole pressure of the atmosphere, the weight of cd is equivalent to the elasticity of the included air. While therefore ce is the measure of the elasticity of the surrounding atmosphere, cd will be the measure of the elasticity of the included air; and since the air originally occupied the space ab, and has now expanded into ad, we have $\frac{ab}{ad}$ for the measure of its density. N. B. ce and cd are measured by the *perpendicular heights* of the columns, but ab and ad must be measured by their *solid capacities*.

Fig. 67. Fig. 68.

By raising the inner tube still higher, the mercury 207 will also rise higher, and the included air will expand still farther, and we obtain another cd, and another $\frac{ab}{ad}$; and in this manner the relation between the density and elasticity of rarefied air may be discovered.

208 This examination may be managed more easily by means of the air-pump. Suppose a tube ae (fig. 69.) containing a small quantity of air ab, set up in a cistern of mercury, which is supported in the tube at the height eb,

An easier method by means of the air-pump. Fig. 69.

Experiments on Air.

e b, and let *e c* be the height of the mercury in the barometer. Let this apparatus be set under a tubulated receiver on the pump-plate, and let *g n* be the pump-gage, and *m n* be made equal to *c e*.

Then, as has been already shown, *c b* is the measure of the elasticity of the air in *a b*, corresponding to the bulk *a b*. Now let some air be abstracted from the receiver. The elasticity of the remainder will be diminished by its expansion; and therefore the mercury in the tube *a e* will descend to some point *d*. For the same reason, the mercury in the gage will rise to some point *o*, and *m o* will express the elasticity of the air in the receiver. This would support the mercury in the tube *a e* at the height *e r*, if the space *a r* were entirely void of air. Therefore *r d* is the effect and measure of the elasticity of the included air when it has expanded to the bulk *a d*; and thus its elasticity, under a variety of other bulks, may be compared with its elasticity when of the bulk *a b*. When the air has been so far abstracted from the receiver that the mercury in *a e* descends to *e*, then *m o* will be the precise measure of its elasticity.

In all these cases it is necessary to compare its bulk *a b* with its natural bulk, in which its elasticity balances the pressure of the atmosphere. This may be done by laying the tube *a e* horizontally, and then the air will collapse into its ordinary bulk.

209 Another easy method. Fig. 70.

Another easy method may be taken for this examination. Let an apparatus *a b c d e f* (fig. 70.) be made, consisting of a horizontal tube *a e* of even bore, a ball *d g e* of a large diameter, and a swan-neck tube *h f*. Let the ball and part of the tube *g e b* be filled with mercury, so that the tube may be in the same horizontal plane with the surface *d e* of the mercury in the ball. Then seal up the end *a*, and connect *f* with an air-pump. When the air is abstracted from the surface *d e*, the air in *a b* will expand into a larger bulk *a c*, and the mercury in the pump-gage will rise to some distance below the barometric height. It is evident that this distance, without any farther calculation, will be the measure of the elasticity of the air pressing on the surface *d e*, and therefore of the air in *a e*.

210 The most exact mode of examining this elasticity.

The most exact of all methods is to suspend in the receiver of an air-pump a glass vessel, having a very narrow mouth, over a cistern of mercury, and then abstract the air till the gage rises to some determined height. The difference *e* between this height and the barometric height determines the elasticity of the air in the receiver and in the suspended vessel. Now lower down that vessel by the slip-wire till its mouth is immersed into the mercury, and admit the air into the receiver; it will press the mercury into the little vessel. Lower it still farther down, till the mercury within it is level with that without; then stop its mouth, take it out and weigh the mercury, and let its weight be *w*. Subtract this weight from the weight *v* of the mercury, which would completely fill the whole vessel; then the natural bulk of the air will be $v-w$, while its bulk, when of the elasticity *e* in the rarefied receiver, was the bulk or capacity *w* of the vessel. Its density therefore, corresponding to this elasticity *e*, was $\frac{v-w}{w}$. And thus may the relation between the density and elasticity in all cases be obtained.

A great variety of experiments to this purpose have been made, with different degrees of attention, according to the interest which the philosophers had in the result. Those made by M. de Luc, General Roy, Mr Trembley, and Sir George Shuckburgh, are by far the most accurate; but they are all confined to very moderate rarefactions. The general result has been, that the elasticity of rarefied air is very nearly proportional to its density. We cannot say with confidence that any regular deviation from this law has been observed, there being as many observations on one side as on the other; but we think that it is not unworthy the attention of philosophers to determine it with precision in the cases of extreme rarefaction, where the irregularities are most remarkable. The great source of error is a certain adhesive sluggishness of the mercury when the impelling forces are very small; and other fluids can hardly be used, because they either smear the inside of the tube and diminish its capacity, or they are converted into vapour, which alters the law of elasticity.

Boylean Law. 211 Various experiments have been made to this purpose.

212 The Boylean law may in general be assumed.

Let us, upon the whole, assume the Boylean law, *viz*. that the elasticity of the air is proportional to its density. The law deviates not in any sensible degree from the truth in those cases which are of the greatest practical importance, that is, when the density does not much exceed or fall short of that of ordinary air.

213 Investigation of the action of the particles on each other.

Let us now see what information this gives us with respect to the action of the particles on each other.

The investigation is extremely easy. We have seen that a force eight times greater than the pressure of the atmosphere will compress common air into the eighth part of its common bulk, and give it eight times its common density: and in this case we know, that the particles are at half their former distance, and that the number which are now acting on the surface of the piston employed to compress them is quadruple of the number which act on it when it is of the common density. Therefore, when this eightfold compressing force is distributed over a fourfold number of particles, the portion of it which acts on each is double. In like manner, when a compressing force 27 is employed, the air is compressed into $\frac{1}{27}$ of its former bulk, the particles are at $\frac{1}{3}$ of their former distance, and the force is distributed among 9 times the number of particles; the force on each is therefore 3. In short, let $\frac{1}{x}$ be the distance of the particles, the number of them in any given vessel, and therefore the density will be as x^3, and the number pressing by their elasticity on its whole internal surface will be as x^2. Experiment shows, that the compressing force is as x^3, which being distributed over the number as x^2, will give the force on each as x. Now this force is in immediate equilibrium with the elasticity of the particle immediately contiguous to the compressing surface. This elasticity is therefore as x: and it follows from the nature of perfect fluidity, that the particle adjoining to the compressing surface presses with an equal force on its adjoining particles on every side. Hence we must conclude, that the corpuscular repulsions exerted by the adjoining particles are inversely as their distances from each other, or that the adjoining particles tend to recede from each other with forces inversely proportional to their distances.

214 Sir Isaac Newton was the first who reasoned properly on this subject.

Sir Isaac Newton was the first who reasoned in this manner from the phenomena. Indeed he was the first who had the patience to reflect on the phenomena with any precision. His discoveries in gravitation naturally gave

Boylean Law. gave his thoughts this turn, and he very early hinted his suspicions that all the characteristic phenomena of tangible matter were produced by forces which were exerted by the particles at small and insensible distances: And he considers the phenomena of air as affording an excellent example of this investigation, and deduces from them the law which we have now demonstrated; and says, that air consists of particles which avoid the adjoining particles with forces inversely proportional to their distances from each other. From this he deduces (in the 2d book of his Principles) several beautiful propositions, determining the mechanical constitution of the atmosphere.

215 Limits the action to adjoining particles. But it must be noticed that he limits this action to the *adjoining* particles: and this is a remark of immense consequence, though not attended to by the numerous experimenters who adopt the law.

It is plain that the particles are supposed to act at a distance, and that this distance is variable, and that the forces diminish as the distances increase. A very ordinary air-pump will rarefy the air 125 times. The distance of the particles is now 5 times greater than before; and yet they still repel each other: for air of this density will still support the mercury in a syphon-gage at the height of 0.24, or $\frac{24}{100}$ of an inch; and a better pump will allow this air to expand twice as much, and still leave it elastic. Thus we see that whatever is the distance of the particles of common air, they can act five times farther off. The question comes now to be, Whether, in the state of common air, they really do act five times farther than the distance of the adjoining particles? While the particle *a* acts on the particle *b* with the force 5, does it also act on the particle *c* with the force 2.5, on the particle *d* with the force 1.667, on the particle *e* with the force 1.25, on the particle *f* with the force 1, on the particle *g* with the force 0.8333, &c.?

216 Sir Isaac Newton shows in the plainest manner, that this is by no means the case; for if this were the case, he makes it appear that the sensible phenomena of condensation would be totally different from what we observe. The force necessary for a quadruple condensation would be eight times greater, and for a nonuple condensation the force must be 27 times greater. Two spheres filled with condensed air must repel each other, and two spheres containing air that is rarer than the surrounding air must attract each other, &c. &c. All this will appear very clearly, by applying to air the reasoning which Sir Isaac Newton has employed in deducing the sensible law of mutual tendency of two spheres, which consist of particles attracting each other with forces proportional to the square of the distance inversely.

217 If we could suppose that the particles of air repelled each other with invariable forces at all distances within some small and insensible limit, this would produce a compressibility and elasticity similar to what we observe. For if we consider a row of particles, within this limit, as compressed by an external force applied to the two extremities, the action of the whole row on the extreme points would be proportional to the number of particles, that is, to their distance inversely and to their density: and a number of such parcels, ranged in a straight line, would constitute a row of any sensible magnitude having the same law of compression. But this law of corpuscular force is unlike every thing we observe in nature, and to the last degree improbable. Height of the Atmosphere.

We must therefore continue the limitation of this mutual repulsion of the particles of air, and be contented for the present with having established it as an experimental fact, that the *adjoining* particles of air are kept asunder by forces inversely proportional to their distances: or perhaps it is better to abide by the sensible law, that *the density of air is proportional to the compressing force*. This law is abundantly sufficient for explaining all the subordinate phenomena, and for giving us a complete knowledge of the mechanical constitution of our atmosphere. 218

And in the first place, this view of the compressibility of the air must give us a very different notion of the height of the atmosphere from what we deduced on a former occasion from our experiments. It is found, that when the air is of the temperature 32° of Fahrenheit's thermometer, and the mercury in the barometer stands at 30 inches, it will descend one-tenth of an inch if we take it to a place 87 feet higher. Therefore, if the air were equally dense and heavy throughout, the height of the atmosphere would be $30 \times 10 \times 87$ feet, or 5 miles and 100 yards. But the loose reasoning adduced on that occasion was enough to show us that it must be much higher; because every stratum as we ascend must be successively rarer as it is less compressed by incumbent weight. Not knowing to what degree air expanded when the compression was diminished, we could not tell the successive diminutions of density and consequent augmentation of bulk and height; we could only say, that several atmospheric appearances indicated a much greater height. Clouds have been seen much higher; but the phenomenon of the twilight is the most convincing proof of this. There is no doubt that the visibility of the sky or air is owing to its want of perfect transparency, each particle (whether of matter purely aerial or heterogeneous) reflecting a little light. 219 The height of the air investigated from considering its compressibility, &c.

Let *b* (fig. 71.) be the last particle of illuminated air which can be seen in the horizon by a spectator at A. This must be illuminated by a ray SD *b*, touching the earth's surface at some point D. Now it is a known fact, that the degree of illumination called *twilight* is perceived when the sun is 18° below the horizon of the spectator, that is, when the angle E *b* S or ACD is 18 degrees; therefore *b* C is the secant of 9 degrees (it is less, viz. about $8\frac{1}{2}$ degrees, on account of refraction). We know the earth's radius to be about 3970 miles: hence we conclude *b* B to be about 45 miles; nay, a very sensible illumination is perceptible much farther from the sun's place than this, perhaps twice as far, and the air is sufficiently dense for reflecting a sensible light at the height of nearly 200 miles. 220 Fig. 71.

We have now seen that air is prodigiously expansible. None of our experiments have distinctly shown us any limit. But it does not follow that it is expansible without end; nor is this at all likely. It is much more probable that there is a certain distance of the parts in which they no longer repel each other; and this would be the distance at which they would arrange themselves if they were not heavy. But at the very summit of the atmosphere they will be a very small matter nearer to each other, on account of their gravitation to the earth. 221 Experiment fixes no limit to the air's expansibility.

Till

Height of the Atmosphere.

Till we know precisely the law of this mutual repulsion, we cannot say what is the height of the atmosphere.

222 Farther observations on, and investigation of, the height of the atmosphere.

But if the air be an elastic fluid whose density is always proportionable to the compressing force, we can tell what is its density at any height above the surface of the earth: and we can compare the density so calculated with the density discovered by observation: for this last is measured by the height at which it supports mercury in the barometer. This is the direct measure of the pressure of the external air; and as we know the law of gravitation, we can tell what would be the pressure of air having the calculated density in all its parts.

223 Let us therefore suppose a prismatic or cylindric column of air reaching to the top of the atmosphere. Let this be divided into an indefinite number of strata of very small and equal depths or thickness; and let us, for greater simplicity, suppose at first that a particle of air is of the same weight at all distances from the centre of the earth.

224 The absolute weight of any one of these strata will on these conditions be proportional to the number of particles or the gravity of air contained in it; and since the depth of each stratum is the same, this quantity of air will evidently be as the density of the stratum: but the density of any stratum is as the compressing force; that is, as the pressure of the strata above it; that is, as their weight; that is, as their quantity of matter—therefore the quantity of air in each stratum is proportional to the quantity of air above it; but the quantity in each stratum is the difference between the column incumbent on its bottom and on its top: these differences are therefore proportional to the quantities of which they are the differences. But when there is a series of quantities which are proportional to their own differences, both the quantities and their differences are in continual or geometrical progression: for let a, b, c, be three such quantities that

$b : c = a - b : b - c$, then by alter.
$b : a - b = c : b - c$ and by compos.
$b : a = c : b$
and $a : b = b : c$

therefore the densities of these strata decrease in a geometrical progression; that is, when the elevations above the centre or surface of the earth increase, or their depths under the top of the atmosphere decrease, in an arithmetical progression, the densities decrease in a geometrical progression.

225 Fig. 72. Let ARQ (fig. 72.) represent the section of the earth by a plane through its centre O, and let mOAM be a vertical line, and AE perpendicular to OA will be a horizontal line through A, a point on the earth's surface. Let AE be taken to represent the density of the air at A; and let DH, parallel to AE, be taken to AE as the density at D is to the density at A: it is evident, that if a logistic or logarithmic curve EHN be drawn, having AN for its axis, and passing through the points E and H, the density of the air at any other point C, in this vertical line, will be represented by CG, the ordinate to the curve in that point: for it is the property of this curve, that if portions AB, AC, AD, of its axis be taken in arithmetical progression, the ordinates, AE, BF, CG, DH, will be in geometrical progression.

It is another fundamental property of this curve, that if EK or HS touch the curve in E or H, the subtangent AK or DS is a constant quantity. 226

And a third fundamental property is, that the infinitely extended area MAEN is equal to the rectangle KA EL of the ordinate and subtangent; and, in like manner, the area MDHN is equal to SD × DH, or to KA × DH; consequently the area lying beyond any ordinate is proportional to that ordinate. 227

These geometrical properties of this curve are all analogous to the chief circumstances in the constitution of the atmosphere, on the supposition of equal gravity. The area MCGN represents the whole quantity of aereal matter which is above C: for CG is the density at C, and CD is the thickness of the stratum between C and D; and therefore CGHD will be as the quantity of matter or air in it; and in like manner of all the others, and of their sums, or the whole area MCGN: and as each ordinate is proportional to the area above it, so each density, and the quantity of air in each stratum, is proportional to the quantity of air above it: and as the whole area MAEN is equal to the rectangle KAEL, so the whole air of variable density above A might be contained in a column KA, if, instead of being compressed by its own weight, it were without weight, and compressed by an external force equal to the pressure of the air at the surface of the earth. In this case, it would be of the uniform density AE, which it has at the surface of the earth, making what we have repeatedly called the homogeneous atmosphere. 228

Hence we derive this important circumstance, that the height of the homogeneous atmosphere is the subtangent of that curve whose ordinates are as the densities of the air at different heights, on the supposition of equal gravity. This curve may with propriety be called the ATMOSPHERICAL LOGARITHMIC: and as the different logarithmics are all characterised by their subtangents, it is of importance to determine this one. 229

It may be done by comparing the densities of mercury and air. For a column of air of uniform density, reaching to the top of the homogeneous atmosphere, is in equilibrio with the mercury in the barometer. Now it is found, by the best experiments, that when mercury and air are of the temperature 32° of Fahrenheit's thermometer, and the barometer stands at 30 inches, the mercury is nearly 10440 times denser than air. Therefore the height of the homogeneous atmosphere is 10440 times 30 inches, or 26100 feet, or 8700 yards, or 4350 fathoms, or 5 miles wanting 100 yards.

Or it may be found by observations on the barometer. It is found, that when the mercury and air are of the above temperature, and the barometer on the sea-shore stands at 30 inches, if we carry it to a place 884 feet higher it will fall to 29 inches. Now, in all logarithmic curves having equal ordinates, the portions of the axes intercepted between the corresponding pairs of ordinates are proportional to the subtangents. And the subtangents of the curve belonging to our common tables is 0.4342945, and the difference of the logarithms of 30 and 29 (which is the portion of the axis intercepted between the ordinates 30 and 29), or 0.0147233, is to 0.4342945 as 883 is to 26058 feet, or 8686 yards, or 4343 fathoms, or 5 miles wanting 114 yards. This determination is 14 yards less than the other, and it is uncertain which is the more exact. It is extremely difficult 230

to

Height of the Atmosphere.

to measure the respective densities of mercury and air; and in measuring the elevation which produces a fall of one inch in the barometer, an error of $\frac{1}{10}$ of an inch would produce all the difference. We prefer the last, as depending on fewer circumstances.

But all this investigation proceeds on the supposition of equal gravity, whereas we know that the weight of a particle of air decreases as the square of its distance from
231 the centre of the earth increases. In order, therefore, that a superior stratum may produce an equal pressure at the surface of the earth, it must be denser, because a particle of it gravitates less. The density, therefore, at equal elevations, must be greater than on the supposition of equal gravity, and the law of diminution of density must be different.

$$\text{Make } OD : OA = OA : Od;$$
$$OC : OA = OA : Oc;$$
$$OB : OA = OA : Ob; \text{ \&c.};$$

so that Od, Oc, Ob, OA, may be reciprocals to OD, OC, OB, OA; and through the points A, b, c, d, draw the perpendiculars AE, bf, cg, dh, making them proportional to the densities in A, B, C, D: and let us suppose CD to be exceedingly small, so that the density may be supposed uniform through the whole stratum. Thus we have

$$OD \times Od = OA^2, = OC \times Oc$$
$$\text{and } Oc : Od = OD : OC;$$
$$\text{and } Oc : Oc - Od = OD : OD - OC,$$
$$\text{or } Oc : cd = OD : DC;$$
$$\text{and } cd : CD = Oc : OD;$$

or, because OC and OD are ultimately in the ratio of equality, we have

$$cd : CD = Oc : OC = OA^2 : OC^2,$$

and $cd = CD \times \frac{OA^2}{OC^2}$, and $cd \times cg = CD \times cg \times \frac{OA^2}{OC^2}$;

but $CD \times cg \times \frac{OA^2}{OC^2}$ is as the pressure at C arising from the absolute weight of the stratum CD. For this weight is as the bulk, as the density, and as the gravitation of each particle jointly. Now CD expresses the bulk, cg the density, and $\frac{OA^2}{OC^2}$ the gravitation of each particle. Therefore, $cd \times cg$ is as the pressure on C arising from the weight of the stratum DC; but $cd \times cg$ is evidently the element of the curvilineal area AmnE, formed by the curve E$fghn$ and the ordinates AE, bf, cg, ah, &c. mn. Therefore the sum of all the elements, such as $cdhg$, that is, the area $cmng$ below cg, will be as the *whole* pressure on C, arising from the gravitation of all the air above it; but, by the nature of air, this whole pressure is as the density which it produces, that is, as cg. Therefore the curve Egn is of such a nature that the area lying below or beyond any ordinate cg is proportional to that ordinate. This is the property of the logarithmic curve, and Egn is a logarithmic curve.

232 But farther, this curve is the same with EGN. For let B continually approach to A, and ultimately coincide with it. It is evident that the ultimate ratio of BA to Ab, and of BF to bf, is that of equality; and if EFK, Efk, be drawn, they will contain equal angles with the ordinate AE, and will cut off equal subtangents AK, Ak. The curves EGN, Egn are therefore the same, but in opposite positions.

Lastly, if OA, Ob, Oc Od, &c. be taken in arithmetical progression decreasing, their reciprocals OA, OB, OC, OD, &c. will be in harmonical progression increasing, as is well known: but, from the nature of the logarithmic curve, when OA, Ob, Oc, Od, &c. are 233
in arithmetical progression, the ordinates AE, bf, cg, dh, &c. are in geometrical progression. Therefore when OA, OB, OC, OD, &c. are in harmonical progression, the densities of the air at A, B, C, D, &c. are in geometrical progression; and thus may the density of the air at all elevations be discovered. Thus to find the density of the air at K the top of the homogeneous atmosphere, make OK : OA=OA : OL, and draw the ordinate LT, LT is the density at K.

The celebrated Dr Halley was the first who observed the relation between the density of the air and the ordinates of the logarithmic curve, or common logarithms. This he did on the supposition of equal gravity; and his discovery is acknowledged by Sir Isaac Newton in *Princip.* ii. *prop.* 22. *schol.* Halley's dissertation on the subject is in N° 185 of the Phil. Trans. Newton, with his usual sagacity, extended the same relation to the true state of the case, where gravity is as the square of the distance inversely; and showed that when the distances from the earth's centre are in harmonic progression, the densities are in geometric progression. He shows indeed, in general, what progression of the distance, on any supposition of gravity, will produce a geometrical progression of the densities, so as to obtain a set of lines OA, Ob, Oc, Od, &c. which will be logarithms of the densities. The subject was afterwards treated in a more familiar manner by Cotes in his *Hydrost. Lect.* and in his *Harmonia Mensurarum*; also by Dr Brook Taylor, *Meth. Increment.*; Wolf in his *Aerometria*; Herman in his *Phoronomia*; &c. &c. and lately by Horsley, Phil. Trans. tom. lxiv.

234 The air has a finite density at an infinite distance from the centre of the earth.

An important corollary is deducible from these principles, viz. that the air has a finite density at an infinite distance from the centre of the earth, namely, such as will be represented by the ordinate OP drawn through the centre. It may be objected to this conclusion, that it would infer an infinity of matter in the universe, and that it is inconsistent with the phenomena of the planetary motions, which appear to be performed in a space void of all resistance, and therefore of all matter. But this fluid must be so rare at great distances, that the resistance will be insensible, even though the retardation occasioned by it has been accumulated for ages. Even at the very moderate distance of 500 miles, the rarity is so great that a cubic inch of common air expanded to that degree would occupy a sphere equal to the orbit of Saturn; and the whole retardation which this planet would sustain after some millions of years would not exceed what would be occasioned by its meeting one bit of matter of half a grain weight.

This being the case, it is not unreasonable to suppose the visible universe occupied by air, which, by its gravitation, will accumulate itself round every body in it, in a proportion depending on their quantities of matter, the larger bodies attracting more of it than the smaller ones, and thus forming an atmosphere about each. And many appearances warrant this supposition. Jupiter, Mars, Saturn, and Venus, are evidently surrounded by atmospheres. The constitution of these atmospheres may differ exceedingly from other causes. If the planet

Atmospheres of the other Planets, &c.

net has nothing on its surface which can be dissolved by the air or volatilized by heat, the atmosphere will be continually clear and transparent, like that of the moon.

235 The atmosphere of Mars.

Mars has an atmosphere which appears precisely like our own, carrying clouds, or depositing snows: for when, by the obliquity of his axis to the plane of his ecliptic, he turns his north pole towards the sun, it is observed to be occupied by a broad white spot. As the summer of that region advances, this spot gradually wastes, and sometimes vanishes, and then the south pole comes in sight, surrounded in like manner with a white spot, which undergoes similar changes. This is precisely the appearance which the snowy circumpolar regions of this earth will exhibit to an astronomer on Mars. It may not, however, be snow that we see; thick clouds will have the same appearances.

236 Of Jupiter.

The atmosphere of the planet Jupiter is also very similar to our own. It is diversified by streaks or belts parallel to his equator, which frequently change their appearance and dimensions, in the same manner as those tracks of similar sky which belong to different regions of this globe. There is a certain kind of weather that more properly belongs to a particular climate than to any other. This is nothing but a certain general state of the atmosphere which is prevalent there, though with considerable variations. This must appear to a spectator in the moon like a streak spread over that climate, distinguishing it from others. But the most remarkable similarity is in the motion of the clouds on Jupiter. They have plainly a motion from east to west relative to the body of the planet: for there is a remarkable spot on the surface of the planet, which is observed to turn round the axis in 9h. 51′ 16″; and there frequently appear variable and perishing spots in the belts, which sometimes last for several revolutions. These are observed to circulate in 9. 55. 05. These numbers are the results of a long series of observations by Dr Herschel. This plainly indicates a general current of the clouds westward, precisely similar to what a spectator in the moon must observe in our atmosphere arising from the trade-winds. Mr Schroeter has made the atmosphere of Jupiter a study for many years; and deduces from his observations that the motion of the variable spots is subject to great variations, but is always from east to west. This indicates variable winds.

237 Of Venus.

The atmosphere of Venus appears also to be like ours, loaded with vapours, and in a state of continual change of absorption and precipitation. About the middle of the 17th century the surface of Venus was pretty distinctly seen for many years chequered with irregular spots, which are described by Campani, Bianchini, and other astronomers in the south of Europe, and also by Cassini at Paris, and Hooke and Townley in England. But the spots became gradually more faint and indistinct; and, for near a century, have disappeared. The whole surface appears now of one uniform brilliant white. The atmosphere is probably filled with a reflecting vapour, thinly diffused through it, like water faintly tinged with milk. A great depth of this must appear as white as a small depth of milk itself; and it appears to be of a *very great* depth, and to be refractive like our air. For Dr Herschel has observed, by the help of his fine telescopes, that the illuminated part of Venus is considerably more than a hemisphere, and that the light dies gradually away to the bounding margin. This is the very appearance that the earth would make if furnished with such an atmosphere. The boundary of illumination would have a penumbra reaching about nine degrees beyond it. If this be the constitution of the atmosphere of Venus, she may be inhabited by beings like ourselves. They would not be dazzled by the intolerable splendor of a sun four times as big and as bright, and sixteen times more glaring, than ours: for they would seldom or never see him, but instead of him an uniformly bright and white sky. They would probably never see a star or planet, unless the dog-star and Mercury; and perhaps the earth might pierce through the bright haze which surrounds their planet. For the same reason the inhabitants would not perhaps be incommoded by the sun's heat. It is indeed a very questionable thing, whether the sun would cause any heat, even here, if it were not for the chemical action of his rays on our air. This is rendered not improbable by the intense cold felt on the tops of the highest mountains, in the clearest air, and even under a vertical sun in the torrid zone.

238 And of comets.

The atmosphere of comets seems of a nature totally different. This seems to be of inconceivable rarity, even when it reflects a very sensible light. The tail is always turned nearly away from the sun. It is thought that this is by the impulse of the solar rays. If this be the case, we think it might be discovered by the aberration and the refraction of the light by which we see the tail: for this light must come to our eye with a much smaller velocity than the sun's light, if it be reflected by repulsive or elastic forces, which there is every reason in the world to believe; and therefore the velocity of the reflected light will be diminished by all the velocity communicated to the reflecting particles. This is almost inconceivably great. The comet of 1680 went half round the sun in ten hours, and had a tail at least a hundred millions of miles long, which turned round at the same time, keeping nearly in the direction opposite to the sun. The velocity necessary for this is prodigious, approaching to that of light. And perhaps the tail extends much farther than we see it, but is visible only as far as the velocity with which its particles recede from the sun is less than a certain quantity, namely, what would leave a sufficient velocity for the reflected light to enable it to affect our eyes. And it may be demonstrated, that although the real form of the visible tail is concave on the anterior side to which the comet is moving, it may appear convex on that side, in consequence of the very great aberration of the light by which the remote parts are seen. All this may be discovered by properly contrived observations; and the conjecture merits attention. But of this digression there is enough; and we return to our subject, the constitution of our air.

239 The barometer used in taking heights.

We have shown how to determine *à priori* the density of the air at different elevations above the surface of the earth. But the densities may be discovered in all accessible elevations by experiments; namely, by observing the heights of the mercury in the barometer. This is a direct measure of the pressure of the incumbent atmosphere; and this is proportional to the density which it produces.

Therefore, by means of the relation subsisting between the densities and the elevations, we can discover the elevations by observations made on the densities by means of 240

Barometer.

of the barometer; and thus we may meafure elevations by means of the barometer; and, with very little trouble, take the level of any extenfive track of country. Of this we have an illuftrious example in the fection which the Abbè Chappe D'Auteroche has given of the whole country between Breft and Ekaterineburgh in Siberia. This is a fubject which deferves a minute confideration: we fhall therefore prefent it under a very fimple and familiar form; and trace the method through its various fteps of improvement by De Luc, Roy, Shuckburgh, &c.

241 Explanation of its ufe, &c.

We have already obferved, oftener than once, that if the mercury in the barometer ftands at 30 inches, and if the air and mercury be of the temperature 32° in Fahrenheit's thermometer, a column of air 87 feet thick has the fame weight with a column of mercury $\frac{1}{10}$ of an inch thick. Therefore, if we carry the barometer to a higher place, fo that the mercury finks to 29.9, we have afcended 87 feet. Now, fuppofe we carry it ftill higher, and that the mercury ftands at 29.8; it is required to know what height we have now got to? We have evidently afcended through another ftratum of equal weight with the former: but it muft be of greater thicknefs, becaufe the air in it is rarer, being lefs compreffed. We may call the denfity of the firft ftratum 300, meafuring the denfity by the number of tenths of an inch of mercury which its elafticity proportional to its denfity enables it to fupport. For the fame reafon, the denfity of the fecond ftratum muft be 299: but when the weights are equal, the bulks are inverfely as the denfities; and when the bafes of the ftrata are equal, the bulks are as the thickneffes. Therefore, to obtain the thicknefs of this fecond ftratum, fay $299:300=87:87.29$; and this fourth term is the thicknefs of the fecond ftratum, and we have afcended in all 174.29 feet. In like manner we may rife till the barometer fhows the denfity to be 298: then fay, $298:30=87:87.584$ for the thicknefs of the third ftratum, and 261,875 or $261\frac{7}{8}$ for the whole afcent; and we may proceed in the fame way for any number of mercurial heights, and make a table of the correfponding elements as follows: Where the firft column is the height of the mercury in the barometer, the fecond column is the thicknefs of the ftratum, or the elevation above the preceding ftation; and the third column is the whole elevation above the firft ftation.

Bar.	Strat.	Elev.
30	00.000	00.000
29.9	87.000	87.000
29.8	87.291	174.291
29.7	87.584	261.875
29.6	87.879	349.754
29.5	88.176	437.930
29.4	88.475	526.405
29.3	88.776	615.181
29.2	89.079	704.260
29.1	89.384	793.644
29	89.691	883.335

242 Having done this, we can now meafure any elevation within the limits of our table, in this manner.

Obferve the barometer at the lower and at the upper ftations, and write down the correfponding elevations. Subtract the one from the other, and the remainder is the height required. Thus fuppofe that at the lower ftation the mercurial height was 29.8, and that at the upper ftation it was 29.1.

Taking Heights.

29.1	793.644
29.8	174.291
	619.353 = Elevation.

We may do the fame thing with tolerable accuracy without the table, by taking the medium m of the mercurial heights, and their difference d in tenths of an inch; and then fay, as m to 300, fo is $87d$ to the height required h: or $h=\frac{300\times 87d}{m}=\frac{26100d}{m}$. Thus, in the foregoing example, m is 294.5, and d is $=7$; and therefore $h=\frac{7\times 26100}{294.5}=620.4$, differing only one foot from the former value.

Either of thefe methods is fufficiently accurate for moft purpofes, and even in very great elevations will not produce any error of confequence: the whole error of the elevation 883 feet 4 inches, which is the extent of the above table, is only $\frac{1}{4}$ of an inch.

But we need not confine ourfelves to methods of approximation, when we have an accurate and fcientific method that is equally eafy. We have feen that, upon the fuppofition of equal gravity, the denfities of the air are as the ordinates of a logarithmic curve, having the line of elevations for its axis. We have alfo feen that, in the true theory of gravity, if the diftances from the centre of the earth increafe in a harmonic progreffion, the logarithm of the denfities will decreafe in an arithmetical progreffion; but if the greateft elevation above the furface be but a few miles, this harmonic progreffion will hardly differ from an arithmetical one. Thus, if A b, A c, A d, are 1, 2, and 3 miles, we fhall find that the correfponding elevations AB, AC, AD are fenfibly in arithmetical progreffion alfo; for the earth's radius AC is nearly 4000 miles. Hence it plainly follows, that BC—AB is $\frac{1}{4000\times 4001}$, or $\frac{1}{16004000}$ of a mile, or $\frac{1}{250}$ of an inch; a quantity quite infignificant. We may therefore affirm without hefitation, that in all acceffible places, the elevations increafe in an arithmetical progreffion, while the denfities decreafe in a geometrical progreffion. Therefore the ordinates are proportional to the numbers which are taken to meafure the denfities, and the portions of the axis are proportional to the logarithms of thefe numbers. It follows, therefore, that we may take fuch a fcale for meafuring the denfities that the logarithms of the numbers of this fcale fhall be the very portions of the axis; that is, of the vertical line in feet, yards, fathoms, or what meafure we pleafe: and we may, on the other hand, choofe fuch a fcale for meafuring our elevations, that the logarithms of our fcale of denfities fhall be parts of this fcale of elevations; and we may find either of thefe fcales fcientifically. For it is a known property of the logarithmic curves, that when the ordinates are the fame, the intercepted portion of the abfciffæ are proportioned to their fubtangents. Now we know the fubtangent of the atmofpherical logarithmic: it is the height of the homogeneous atmofphere in any meafure we pleafe, fuppofe fathoms: we find this height by comparing the gravities of air and mercury, when both

Barometer. both are of some determined density. Thus, in the temperature of 32° of Fahrenheit's thermometer, when the barometer stands at 30 inches, it is known (by many experiments) that mercury is 10423.068 times heavier than air; therefore the height of the balancing column of homogeneous air will be 10423.068 times 30 inches; that is, 4342.945 English fathoms. Again, it is known that the subtangent of our common logarithmic tables, where 1 is the logarithm of the number 10, is 0.4342945. Therefore the number 0.4342945 is to the difference D of the logarithms of any two barometric heights as 4342.945 fathoms are to the fathoms F contained in the portion of the axis of the atmospherical logarithmic, which is intercepted between the ordinates equal to these barometrical heights; or that $0.4342945 : D = 4342.945 : F$, and $0.4342,945 : 4342.945 = D : F$; but 0.4342945 is the ten-thousandth part of 4342.945, and therefore D is the ten-thousandth part of F.

244 And thus it happens, by mere chance, that the logarithms of the densities, measured by the inches of mercury which their elasticity supports in the barometer, are just the ten-thousandth part of the fathoms contained in the corresponding portions of the axis of the atmospherical logarithmic. Therefore, if we multiply our common logarithms by 10000, they will express the fathoms of the axis of the atmospherical logarithmic; nothing is more easily done. Our logarithms contain what is called the index or characteristic, which is an integer and a number of decimal places. Let us just remove the integer-place four figures to the right hand: thus the logarithm of 60 is 1.7781513, which is one integer and $\frac{7781513}{10000000}$. Multiply this by 10.000, and we obtain $\frac{513}{1001}$ 17781.513, or 17781 $\frac{513}{1000}$.

245 The practical application of all this reasoning is obvious and easy: observe the heights of the mercury in the barometer at the upper and lower stations in inches and decimals; take the logarithms of these, and subtract the one from the other: the difference between them (accounting the four first decimal figures as integers) is the difference of elevation of fathoms.

Example.

Merc. Height at the lower station	29.8	1.4742163
upper station	29.1	1.4638930
Diff. of Log. × 10000		0.0103.233

or 103 fathoms and $\frac{233}{1000}$ of a fathom, which is 619.392 feet, or 619 feet $4\frac{1}{4}$ inches; differing from the approximated value formerly found about $\frac{1}{4}$ an inch.

246 This method of measuring heights now much improved.

Such is the general nature of the barometric measurement of heights first suggested by Dr Halley; and it has been verified by numberless comparisons of the heights calculated in this way with the same heights measured geometrically. It was indeed in this way that the precise specific gravity of air and mercury was most accurately determined; namely, by observing, that when the temperature of air and mercury was 32, the difference of the logarithms of the mercurial heights were precisely the fathoms of elevation. But it requires many corrections to adjust this method to the circumstances of the case; and it was not till very lately that it has been so far adjusted to them as to become useful. We are chiefly indebted to Mr de Luc for the improvements. The great elevations in Switzerland enabled him to make an immense number of observations, in almost every variety of circumstances. Sir George Shuckburgh also made a great number with most accurate instruments in much greater elevations, in the same country; and he made many chamber experiments for determining the laws of variation in the subordinate circumstances. General Roy also made many to the same purpose. And to these two gentlemen we are chiefly obliged for the corrections which are now generally adopted.

Taking heights.

It is easy to perceive that the method, as already expressed, cannot apply to every case: it depends on the specific gravity of air and mercury, combined with the supposition that this is affected *only by a change of pressure*. But since all bodies are expanded by heat, and as there is no reason to suppose that they are equally expanded by it, it follows that a change of temperature will change the relative gravity of mercury and air, even although both suffer the same change of temperature: and since the air may be warmed or cooled when the mercury is not, or may change its temperature independent of it, we may expect still greater variations of specific gravity. 247

247 It depends on the specific gravity of air and mercury.

The general effect of an augmentation of the specific gravity of the mercury must be to increase the subtangent of the atmospherical logarithmic; in which case the logarithms of the densities, as measured by inches of mercury, will express measures that are greater than fathoms in the same proportion that the subtangent is increased; or, when the air is more expanded than the mercury, it will require a greater height of homogeneous atmosphere to balance 30 inches of mercury, and a given fall of mercury will then correspond to a thicker stratum of air.

In order, therefore, to perfect this method, we must learn by experiment how much mercury expands by an increase of temperature; we must also learn how much the air expands by the same, or any change of temperature; and how much its elasticity is affected by it. Both these circumstances must be considered in the case of air; for it might happen that the elasticity of the air is not so much affected by heat as its bulk is.

It will, therefore, be proper to state in this place the experiments which have been made for ascertaining these two expansions.

248 General Roy's experiments on the expansion of mercury.

The most accurate, and the best adapted experiments for ascertaining the expansion of mercury, are those of General Roy, published in the 67th volume of the Philosophical Transactions. He exposed 30 inches of mercury, actually supported by the atmosphere in a barometer, in a nice apparatus, by which it could be made of one uniform temperature through its whole length; and he noted the expansion of it in decimals of an inch. These are contained in the following table; where the first column expresses the temperature by Fahrenheit's thermometer, the second column expresses the bulk of the mercury, and the third column the expansion of an inch of mercury for an increase of one degree in the adjoining temperatures. 248

Barometer.

TABLE A.

Temp.	Bulk of ☿.	Expan. for 1°
212°	30.5117	0.0000763
202	30.4888	0.0000787
192	30.4652	0.0000810
182	30.4409	0.0000833
172	30.4159	0.0000857
162	30.3902	0.0000880
152	30.3638	0.0000903
142	30.3367	0.0000923
132	30.3090	0.0000943
122	30.2807	0.0000963
112	30.2518	0.0000983
102	30.2223	0.0001003
92	30.1922	0.0001023
82	30.1615	0.0001043
72	30.1302	0.0001063
62	30.0984	0.0001077
52	30.0661	0.0001093
42	30.0333	0.0001110
32	30.0000	0.0001127
22	29.9662	0.0001143
12	29.9319	0.0001160
2	29.8971	0.0000177
0	29.8901	

249 This table gives rise to some reflections. The scale of the thermometer is constructed on the supposition that the successive degrees of heat are measured by equal increments of bulk in the mercury of the thermometer. How comes it, therefore, that this is not accompanied by equal increments of bulk in the mercury of the column, but that the corresponding expansions of this column do continually diminish: General Roy attributes this to the gradual detachment of elastic matter from the mercury by heat, which presses on the top of the column, and therefore shortens it. He applied a boiling heat to the vacuum a-top, without producing any farther depression; a proof that the barometer had been carefully filled. It had indeed been boiled through its whole length. He had attempted to measure the mercurial expansion in the usual way, by filling 30 inches of the tube with boiled mercury, and exposing it to the heat with the open end uppermost. But here it is evident that the expansion of the tube, and its solid contents, must be taken into the account. The expansion of the tube was found so exceedingly irregular, and so incapable of being determined with precision for the tubes which were to be employed, that he was obliged to have recourse to the method with the real barometer. In this no regard was necessary to any circumstance but the perpendicular height. There was, besides, a propriety in examining the mercury in the very condition in which it was used for measuring the pressure of the atmosphere; because whatever complication there was in the results, it was the same in the barometer in actual use.

250 The most obvious manner of applying these experiments on the expansion of mercury to our purpose, is to reduce the observed height of the mercury to what it would have been if it were of the temperature 32. Thus, suppose that the observed mercurial height is 29.2, and that the temperature of the mercury is 72°, make 30.1302 : 30=29.2 : 29.0738. This will be the true measure of the density of the air of the standard temperature. In order that we may obtain the exact temperature of the mercury, it is proper that the observation be made by means of a thermometer attached to the barometer-frame, so as to warm and cool along with it.

Taking heights.

Or, this may be done without the help of a table, and with sufficient accuracy, from the circumstance that the expansion of an inch of mercury for one degree diminishes very nearly $\frac{1}{100}$th part in each succeeding degree. If therefore we take from the expansion at 32° its thousandth part for each degree of any range above it, we obtain a mean rate of expansion for that range. If the observed temperature of the mercury is below 32°, we must *add* this correction to obtain the mean expansion. This rule will be made more exact if we suppose the expansion at 32° to be =0.0001127. Then multiply the observed mercurial height by this expansion, and we obtain the correction, to be subtracted or added according as the temperature of the mercury was above or below 32°. Thus to abide by the former example of 72°. This exceeds 32° by 40: therefore take 40 from 0.0001127, and we have 0.0001087 for the medium expansion for that range. Multiply this by 40, and we have the whole expansion of one inch of mercury, =0.004348. Multiply the inches of mercurial height, viz. 29.2 by this expansion, and we have for the correction 0.12696; which being subtracted from the observed height leaves 29.07304, differing from the accurate quantity less than the thousandth part of an inch. This rule is very easily kept in the memory, and supersedes the use of a table. 251

This correction may be made with all necessary exactness by a rule still more simple; namely, by multiplying the observed height of the mercury by the difference of its temperature from 32°, and cutting off four cyphers before the decimals of the mercurial height. This will seldom err $\frac{1}{100}$ of an inch. We even believe that it is the most exact method within the range of temperatures that can be expected to occur in measuring heights: for it appears, by comparing many experiments and observations, that General Roy's measure of the mercurial expansion is too great, and that the expansion of an inch of mercury between 20° and 70° of Fahrenheit's thermometer does not exceed 0.000102 per degree. Having thus corrected the observed mercurial heights by reducing them to what they would have been if the mercury had been of the standard temperature, the logarithms of the corrected heights are taken, and their difference, multiplied by 10000, will give the difference of elevations in English fathoms. 252

There is another way of applying this correction, fully more expeditious and equally accurate. The difference of the logarithms of the mercurial heights is the measure of the ratio of those heights. In like manner the difference of the logarithms of the observed and corrected heights at any station is the measure of the ratio of those heights. Therefore this last difference of the logarithms is the measure of the correction of this ratio. Now the observed height is to the corrected height nearly as 1 to 1.000102. The logarithm of this ratio, or the difference of the logarithms of 1 and 1.000102, is 0.0000444. This is the correction for each degree that 253 that the temperature of the mercury differs from 32. Therefore multiply 0.0000444 by the difference of the mercurial temperatures from 32, and the products will be the corrections of the respective logarithms.

254 But there is still an easier way of applying the logarithmic correction. If both the mercurial temperatures are the same, the differences of their logarithms will be the same, although each may be a good deal above or below the standard temperature, if the expansion be very nearly equable. The correction will be necessary only when the temperatures at the two stations are different, and will be proportional to this difference. Therefore, if the difference of the mercurial temperatures be multiplied by 0.0000444, the product will be the correction to be made on the difference of the logarithms of the mercurial heights.

But farther, since the differences of the logarithms of the mercurial heights are also the differences of elevation in English fathoms, it follows that the correction is also a difference of elevation in English fathoms, or that the correction for one degree of difference of mercurial temperature is $\frac{444}{1000}$ of a fathom, or 32 inches, or 2 feet 8 inches.

This correction of 2.8 for every degree of difference of temperature must be subtracted from the elevation found by the general rate, when the mercury at the upper station is colder than that at the lower. For when this is the case, the mercurial column at the upper station will appear too short, the pressure of the atmosphere too small, and therefore the elevation in the atmosphere will appear greater than it really is.

255 Therefore the rule for this correction will be to multiply 0.0000444 by the degrees of difference between the mercurial temperatures at the two stations, and to add or subtract the product from the elevation found by the general rule, according as the mercury at the upper station is hotter or colder than at the lower.

256 If the experiments of General Roy on the expansion of the mercury in a real barometer be thought most deserving of attention, and the expansion be considered as variable, the logarithmic difference corresponding to this expansion for the *mean* temperature of the two barometers may be taken. These logarithmic differences are contained in the following table, which is carried as far as 112°, beyond which it is not probable that any observations will be made. The number for each temperature is the difference between the logarithms of 30 inches of the temperature 32, and of 30 inches expanded by that temperature.

Table B.

Temp.	Log. diff.	Dec. of Fath.	Ft. In.
112°			
102	0.0000427	.427	2.7
92	0.0000436	.436	2.7
82	0.0000444	.444	2.8
72	0.0000453	.453	2.9
62	0.0000460	.460	2.9
52	0.0000468	.468	2.10
42	0.0000475	.475	2.10
32	0.0000482	.482	2.11
22	0.0000489	.489	2.11
12	0.0000497	.497	3.0
0	0.0000504	.504	3.0

It is also necessary to attend to the temperature of the air; and the change that is produced by heat in its density is of much greater consequence than that of the mercury. The relative gravity of the two, on which the subtangent of the logarithmic curve depends, and consequently the unit of our scale of elevations, is much more affected by the heat of the air than by the heat of the mercury. 257

257 The temperature of the air must also be attended to.

This adjustment is of incomparably greater difficulty than the former, and we can hardly hope to make it perfect. We shall narrate the chief experiments which have been made on the expansion of air, and deduce from them such rules as appear to be necessary consequences of them, and then notice the circumstances which leave the matter still imperfect.

258 Comparison of a mercurial and air thermometer.

General Roy compared a mercurial and an air thermometer, each of which was graduated arithmetically, that is, the units of the scales were equal bulks of mercury, and equal bulks (perhaps different from the former) of air. He found their progress as in the following table.

Table C.

Merc.	Diff.	Air.	Diff.
212		212.0	
	20		17.6
192		194.4	
	20		18.2
172		176.2	
	20		18.8
152		157.4	
	20		19.4
132		138.0	
	20		20.0
112		118.0	
	20		20.8
92		97.2	
	20		21.6
72		75.6	
	20		22.6
52		53.0	
	20		21.6
32		31.4	
	20		20.0
12		11.4	

It has been established by many experiments that equal increments of heat produce equal increments in the bulk of mercury. The differences of temperature are therefore expressed by the second column, and may be considered as equal; and the numbers of the third column must be allowed to express the same temperatures with those of the first. They *directly* express the *bulks* of the air, and the numbers of the fourth column express the differences of these bulks. These are evidently unequal, and show that common air expands most of all when of the temperature 62 nearly. 259

260 To determine an actual increase of bulk from a known increase of heat.

The next point was to determine what was the *actual* increase of bulk by some known increase of heat. For this purpose he took a tube, having a narrow bore, and a ball at one end. He measured with great care the capacity of both the ball and the tube, and divided the tube into equal spaces which bore a determined proportion to the capacity of the ball. This apparatus was set in a long cylinder filled with frigorific mixtures or with water, which could be uniformly heated up to the boiling temperature, and was accompanied by a nice thermometer. The expansion of the air was measured by means of a column of mercury which rose or sunk in the tube. The tube being of a small bore, the mercury did not drop out of it; and the bore being chosen as equable as possible, this column remained of an uniform length, whatever part of the tube it chanced to occupy. By this contrivance he was able to examine the

Barometer. the expansibility of air of various densities. When the column of mercury contained only a single drop or two, the air was nearly of the density of the external air. If he wished to examine the expansion of air twice or thrice as dense, he used a column of 30 or 60 inches long; and to examine the expansion of air that is rarer than the external air, he placed the tube with the ball uppermost, the open end coming through a hole in the bottom of the vessel containing the mixtures or water. By this position the column of mercury was hanging in the tube, supported by the pressure of the atmosphere; and the elasticity of the included air was measured by the difference between the suspended column and the common barometer.

261 The following table contains the expansion of 1000 parts of air, nearly of the common density, by heating it from 0 to 212. The first column contains the height of the barometer; the second contains this height augmented by the small column of mercury in the tube of the manometer, and therefore expresses the density of the air examined; the third contains the total expansion of 1000 parts; and the fourth contains the expansion for 1°, supposing it uniform throughout.

TABLE D.

Barom.	Density of Air examined.	Expansion of 1000 pts by 212°.	Expansion by 1°.
29.95	31.52	483.89	2.2825
30.07	30.77	482.10	2.2741
29.48	29.90	480.74	2.2676
29.90	30.73	485.86	2.2918
29.96	30.92	489.45	2.3087
29.90	30.55	476.04	2.2455
29.95	30.60	487.55	2.2998
30.07	30.60	482.80	2.2774
29.48	30.00	489.47	2.3087
Mean	30.62	484.21	2.2840

Hence it appears, that the mean expansion of 1000 parts of air of the density 30.62 by one degree of Fahrenheit's thermometer is 2.284, or that 1000 becomes 1002.284.

262 If this expansion be supposed to follow the same rate that was observed in the comparison of the mercurial and air thermometer, we shall find that the expansion of a thousand parts of air for one degree of heat at the different intermediate temperatures will be as in the following table.

TABLE E.

Temp.	Total Expansion.	Expansion for 1°.	Temp.	Total Expansion.	Expansion for 1°.
212	484.210	2.0099	72	172.671	2.5581
192	444.011	2.0080	62	147.090	2.6037
172	402.452	2.1475	52	121.053	2.5124
152	359.503	2.2155	42	95.929	2.4211
132	315.193	2.2840	32	71.718	2.3297
112	269.513	2.3754	22	48.421	2.2383
92	222.006	2.4211	12	26.038	2.1698
82	197.795	2.5124	0		
72	172.671				

If we would have a mean expansion for any particular range, as between 12° and 92°, which is the most likely to comprehend all the geodætical observations, we need only take the difference of the bulks 26.038 and 222.006.=195.968, and divide this by the interval of temperature 80°, and we obtain 2.4496, or 2.45 for the mean expansion for 1°. Taking heights.

It would perhaps be better to adapt the table to a mass of 1000 parts of air of the standard temperature 32°; for in its present form it shows the expansibility of air originally of the temperature 0. This will be done with sufficient accuracy by saying (for 212°) 1071.718 : 1484.210=1000. : 13849, and so of the rest. Thus we shall construct the following table of the expansion of 10,000 parts of air. 263

TABLE F.

Temp.	Bulk.	Differ.	Expanf. for 1°.
212	13489	375	18.7
192	13474	387	19.3
172	13087	392	19.6
152	12685	413	20.6
132	12272	426	21.3
112	11846	443	22.1
92	11403	226	22.6
82	11177	235	23.5
72	10942	238	23.8
62	10704	243	24.3
52	10461	235	23.5
42	10226	226	22.6
32	10000	217	21.7
22	9783	209	20.9
12	9574	243	20.2
0	9331		

This will give for the mean expansion of 1000 parts of air between 12° and 92=2.29.

Although it cannot happen that in measuring the differences of elevation near the earth's surface, we shall have occasion to employ air greatly exceeding the common density, we may insert the experiments made by General Roy on such airs. They are expressed in the following table; where column first contains the densities measured by the inches of mercury that they will support when of the temperature 32°: column second is the expansion of 1000 parts of such air by being heated from 0 to 212; and column third is the mean expansion for 1°. 264 General Roy's experiments on air above the common density,

TABLE G.

	Density.	Expansion for 212.	Expanf. for 1°.
	101.7	451.54	2.130
	92.3	423.23	1.996
	80.5	412.09	1.944
	54.5	439.87	2.075
	49.7	443.24	2.091
Mean	75.7	434	2.047

We have much more frequent occasion to operate in air that is rarer than the ordinary state of the superficial atmosphere. 265 And on air below that density.

Barometer. atmosphere. General Roy accordingly made many experiments on such airs. He found in general, that their expansibility by heat was analogous to that of air in its ordinary density, being greatest about the temperature 60°. He found, too, that its expansibility by heat diminished with its density, but he could not determine the law of gradation. When reduced to about one-fifth of the density of common air, its expansion was as follows.

TABLE H.

Temp.	Bulk.	Difference.	Expansion for 1°.
212	1141.504		
		7.075	0.354
192	1134.429		
		12.264	0.613
172	1122.165		
		14.150	0.708
152	1108.015		
		14.151	0.708
132	1093.864		
		14.228	0.711
112	1079.636		
		14.937	0.747
92	1064.699		
		20.911	1.045
72	1043.788		
		25.943	1.297
52	1017.845		
		17.845	0.892
32	1000.000		
	Mean expansion		0.786

266 Air of ordinary density expands most, &c.

From this very extensive and judicious range of experiments, it is evident that the expansibility of air by heat is greatest when the air is about its ordinary density, and that in small densities it is greatly diminished. It appears also, that the law of compression is altered; for in this specimen of the rare air half of the whole expansion happens about the temperature 99°, but in air of ordinary density at 105°. This being the case, we see that the experiments of Mr Amontons, narrated in the Memoirs of the Academy at Paris 1702, &c. are not inconsistent with those more perspicuous experiments of General Roy. Amontons found, that whatever was the density of the air, at least in cases much denser than ordinary air, the change of 180° of temperature increased its elasticity in the same proportion: for he found, that the column of mercury which it supported when of the temperature 50, was increased one-third at the temperature 212. Hence he hastily concluded, that its expansibility was increased in the same proportion; but this by no means follows, unless we are certain that in every temperature the elasticity is proportional to the density. This is a point which still remains undecided; and it merits attention, because if true it establishes a remarkable law concerning the action of heat, which would seem to go to prove that the elasticity of fluids is the property of the matter of fire, which it superinduces on every body with which it combines in the form of vapour.

267 The height which produces a given fall in the barometer, increases with the air's expansion.

After this account of the expansion of air, we see that the height through which we must rise in order to produce a given fall of the mercury in the barometer, or the thickness of the stratum of air equiponderant with a tenth of an inch of mercury, must increase with the expansion of air; and that if $\frac{2.29}{1000}$ be the expansion for one degree, we must multiply the excess of the temperature of the air above 32° by 0.00229, and multiply the product by 87, in order to obtain the thickness of the stratum where the barometer stands at 30 inches: or whatever be the elevation indicated by the difference of the barometrical heights, upon the supposition that the air is of the temperature 32°, we must multiply this by 0.00229 for every degree that the air is warmer or colder than 32. The product must be added to the elevation in the first case, and subtracted in the latter.

Taking heights.

Sir George Shuckburgh deduces 0.0024 from his experiments as the mean expansion of air in the ordinary cases: and this is probably nearer the truth; because General Roy's experiments were made on air which was freer from damp than the ordinary air in the fields: and it appears from his experiments, that a very minute quantity of damp increases its expansibility by heat in a prodigious degree. 268

269 Difficulties in this mode of measuring heights.

The great difficulty is how to apply this correction; or rather, how to determine the temperature of the air in those extensive and deep strata in which the elevations are measured. It seldom or never happens that the stratum is of the same temperature throughout. It is commonly much colder aloft; it is also of different constitutions. Below it is warm, loaded with vapour, and very expansible; above it is cold, much drier, and less expansible, both by its dryness and its rarity. The currents of wind are often disposed in strata, which long retain their places; and as they come from different regions, are of different temperatures and different constitutions. We cannot therefore determine the expansion of the whole stratum with precision, and must content ourselves with an approximation: and the best approximation that we can make is, by supposing the whole stratum of a mean temperature between those of its upper and lower extremity, and employ the expansion corresponding to that mean temperature.

This, however, is founded on a gratuitous supposition, that the whole intermediate stratum expands alike, and that the expansion is equable in the different intermediate temperatures; but neither of these is warranted by experiment. Rare air expands less than what is denser; and therefore the general expansion of the whole stratum renders its density more uniform. Dr Horsley has pointed out some curious consequences of this in Phil. Trans. vol. lxiv. There is a particular elevation at which the general expansion, instead of diminishing the density of the air, increases it by the superior expansion of what is below; and we know that the expansion is not equable in the intermediate temperatures: but we cannot find out a rule which will give us a more accurate correction than by taking the expansion for the mean temperature.

When we have done this, we have carried the method of measuring heights by the barometer as far as it can go; and this source of remaining error makes it needless to attend to some other very minute equations which theory points out. Such is the diminution of the weight of the mercury by the change of distance from the centre of the earth. This accompanies the diminution of the weight of the air, but neither so as to compensate it, nor to go along with it *pari passu*.

After all, there are found cases where there is a regular deviation from those rules, of which we cannot give any very satisfactory account. Thus it is found, that in the province of Quito in Peru, which is at a great elevation above the surface of the ocean, the heights obtained by these rules fall considerably short of the

Barometer. the real heights; and at Spitsbergen they considerably exceed them. It appears that the air in the circumpolar regions is denser than the air of the temperate climates when of the same heat and under the same pressure; and the contrary seems to be the case with the air in the torrid zone. It would seem that the specific gravity of air to mercury is at Spitsbergen about 1 to 10224, and in Peru about 1 to 13100. This difference is with great probability ascribed to the greater dryness of the circumpolar air.

This source of error will always remain; and it is combined with another, which should be attended to by all who practise this method of measuring heights, namely, a difference in the specific gravity of the quicksilver. It is thought sufficiently pure for a barometer when it is cleared of all calcinable matter, so as not to drag or sully the tube. In this state it may contain a considerable portion of other metals, particularly of silver, bismuth, and tin, which will diminish its specific gravity. It has been obtained by revivification from cinnabar of the specific gravity 14.229, and it is thought very fine if 13.65. Sir George Shuckburgh found the quicksilver which agreed precisely with the atmospherical observations on which the rules are founded, to have the specific gravity 13.61. It is seldom obtained so heavy. It is evident that these variations will change the whole results; and that it is absolutely necessary, in order to obtain precision, that we know the density of the mercury employed. The subtangent of the atmospherical logarithmic, or the height of the homogeneous atmosphere, will increase in the same proportion with the density of the mercury; and the elevation corresponding to one-tenth of an inch of barometric height will change in the same proportion.

We must be contented with the remaining imperfections: and we can readily see, that, for any purpose that can be answered by such measurements of great heights, the method is sufficiently exact; but it is quite inadequate to the purpose of taking accurate levels, for directing the construction of canals, aqueducts, and other works of this kind, where extreme precision is absolutely necessary.

We shall now deduce from all that has been said on this subject sets of easy rules for the practice of this mode of measurement, illustrating them by an example.

1. *M. de Luc's Method.*

270 Mode of measuring heights by the barometer according to De Luc,

I. Subtract the logarithm of the barometrical height at the upper station from the logarithm of that at the lower, and count the index and four first decimal figures of the remainder as fathoms, the rest as a decimal fraction. Call this the *elevation.*

II. Note the different temperatures of the mercury at the two stations, and the mean temperature. Multiply the logarithmic expansion corresponding to this mean temperature (in Table B, p. 709.) by the difference of the two temperatures, and subtract the product from the elevation if the barometer has been coldest at the upper station, otherwise add it. Call the difference or the sum the *approximated elevation.*

III. Note the difference of the temperatures of the air at the two stations by a detached thermometer, and also the mean temperature and its difference from 32°. Multiply this difference by the expansion of air for the mean temperature, and multiply the approximate elevation by 1 ± this product, according as the air is above or below 32°. The product is the correct elevation in fathoms and decimals. Measuring heights.

Example.

Suppose that the mercury in the barometer at the lower station was at 29.4 inches, that its temperature was 50°, and the temperature of the air was 45; and let the height of the mercury at the upper station be 25.19 inches, its temperature 46, and the temperature of the air 39. Thus we have

☿al Hts.	Temp. ☿.	Mean.	Temp. Air.	Mean.
29.4	50	48	45	42
25.19	464		30	

I. Log. of 29.4	- - -	1.4683473
Log. of 25.19	- - -	1.4012282
Elevation in fathoms	-	671.191
II. Expans. for 48°	·473	
Multiply -	4	1.892
Approximated elevation	-	669.299
III. Expans. of air at 42	0.00238	
× 42—32,=10°	10	
	0.0238	
Multiply	- -	669.2990
By	- - -	1.0238
Product = the correct elevation		685.228

2. Sir George Shuckburgh's Method.

271 and according to Shuckburgh.

I. Reduce the barometric heights to what they would be if they were of the temperature 32°.

II. The difference of the logarithms of the reduced barometrical heights will give the approximate elevation.

III. Correct the approximated elevation as before.

Same Example.

I. Mean expans. for 1° from Tab. A, is 0.000111.

18° × 0.000111 × 29.4 =	- -	0.059
Subtract this from	- -	29.4
Reduced barometric height	-	29.341
Expans. from Tab. A is 0.000111.		
14° × 0.000111 × 25.19	- -	0.039
Subtract from	- -	25.190
Reduced barometric height	-	25.151
II. Log. 29.341	- -	1.4674749
Log. 25.151	- .	1.4005553
Approximated elevation	-	669.196
III. This multiplied by 1.0238 gives		685.125

Remark. 1. If 0.000101 be supposed the mean expansion of mercury for 1°, as Sir George Shuckburgh determines it, the reduction of the barometric heights will be had sufficiently exact by multiplying the observed heights of the mercury by the difference of its temperatures 272 Remarks on this method.

Barometer. peratures from 32, and cutting off four more decimal places; thus $29.4 \frac{\times 18}{10000}$ gives the reduced height 29.347, and $25.19 \times \frac{14}{10000}$ gives 25.155, and the difference of their logarithms gives 669.4 fathoms for the approximated elevation, which differs from the one given above by no more than 15 inches.

273 *Remark* 2. If 0.0024 be taken for the expansion of air for one degree, the correction for this expansion will be had by multiplying the approximated elevation by 12, and this product by the sum of the differences of the temperatures from 32°, counting the difference as negative when the temperature is below 32, and cutting off four places; thus $669.196 \times 12 \times \overline{13+07} \times \frac{1}{10000} =$ 16.061, which added to 669,196 gives 685.257, differing from the former only 9 inches.

274 An easy rule without the help of tables. From the same premises we may derive a rule, which is abundantly exact for all geodætical purposes, and which requires no tables of any kind, and is easily remembered.

1. The height through which we must rise in order to produce any fall of the mercury in the barometer, is inversely proportional to the density of the air, that is, to the height of the mercury in the barometer.

2. When the barometer stands at 30 inches, and the air and quicksilver are of the temperature 32, we must rise through 87 feet, in order to produce a depression of $\frac{1}{10}$ of an inch.

3. But if the air be of a different temperature, this 87 feet must be increased or diminished by 0.21 of a foot for every degree of difference of the temperature from 32°.

4. Every degree of difference of the temperatures of the mercury at the two stations makes a change of 2.833 feet, or 2 feet 10 inches in the elevation.

Hence the following rule.

275 1. Take the difference of the barometric heights in tenths of an inch. Call this *d*.

2. Multiply the difference *a* between 32, and the mean temperature of the air by 21, and take the sum or difference of this product and 87 feet. This is the height through which we must rise to cause the barometer to fall from 30 inches to 29.9. Call this height *h*.

Let *m* be the mean between the two barometric heights. Then $\frac{30\,hd}{m}$ is the approximated elevation very nearly.

Multiply the difference δ of the mercurial temperatures by 2.83 feet, and add this product to the approximated elevation if the upper barometer has been the warmest, otherwise subtract it. The result, that is, the sum or difference, will be the corrected elevation.

Same Example.

$$d = 294 - 251.9 = 42.1$$
$$b = 87 + 10 \times 0.21, = 89.1$$
$$m = \frac{29.4 + 25.19}{2} = 27.29$$

Approx. elevation $= \frac{30 \times 42.1 \times 89.1'}{27.29}, = 4123.24$ feet.

Measuring Heights.

Corr. for temp. of mercury, $= 4 \times 2.83$	11.32
Corrected elevation in feet	4111.92
Ditto in fathoms	685.32

Differing from the former only 15 inches.

276 This rule may be expressed by the following simple and easily remembered formula, where *a* is the difference between 32° and the mean temperature of the air, *d* is the difference of barometric heights in tenths of an inch, *m* is the mean barometric height, δ the difference between the mercurial temperatures, and E is the correct elevation. $E = \frac{30(87 \pm 0.21a)d}{m} \pm \delta \times 2.83.$

277 Heights of the most remarkable mountains. We shall now conclude this subject by an account of some of the most remarkable mountains, &c. on the earth, above the surface of the ocean, in feet.

Mount Puy de Domme in Auvergne, the first mountain measured by the barometer		5088
Mount Blanc	Alps	15662
Monte Rosa	Alps	15084
Aiguille d'Argenture	Alps	13402
Monastery of St Bernard	Alps	7944
Mount Cenis		9212
Pic de los Reyes	Pyrenees	7620
Pic du Médi	Pyrenees	9300
Pic d'Offano	Pyrenees	11700
Canegou	Pyrenees	8544
Lake of Geneva		1232
Mount Ætna		10954
Mount Vesuvius		3938
Mount Hekla in Iceland		4887
Snowdown		3555
Ben More		3723
Ben Lawers		3858
Ben Gloe		3472
Schehallion		3461
Ben Lomond		3180
Tinto		2342
Table Hill, Cape of Good Hope		3454
Gondar city in Abyssinia		8440
Source of the Nile		8082
Pic of Teneriffe		14026
Chimboraço		19595
Cayambourow		19391
Antisana		19290
Pinchinha ((see Peru, n° 56.)		15670
City of Quito (see ditto)		9977
Caspian sea below the ocean		306

This last is so singular, that it is necessary to give the authority on which this determination is founded. It is deduced from nine years observations with the barometer at Astrachan by Mr Lecre, compared with a series of observations made with the same barometer at St Petersburgh.

278 Improved barometers, with a description of Hooke's. This employment of the barometer has caused it to become a very interesting instrument to the philosopher and to the traveller; and many attempts have been made of late to improve it, and render it more portable. The improvements have either been directed to the enlargement of its range, or to the more accurate measurement of its present scale. Of the first kind are Hooke's wheel barometer, the diagonal barometer, and the horizontal barometer, described in a former part of this work.

work. See BAROMETER. In that place are alſo deſcribed two very ingenious contrivances of Mr Rownings, which are evidently not portable. Of all the barometers with an enlarged ſcale the beſt is that invented by Dr Hooke in 1668, and deſcribed in the Phil. Tranſ. N° 185. The invention was alſo claimed by Huyghens and by De la Hire; but Hooke's was publiſhed long before.

Plate ccccxxx. Fig. 73.

It conſiſts of a compound tube ABCDEFG (fig. 73.), of which the parts AB and DE are equally wide, and EFG as much narrower as we would amplify the ſcale. The parts AB and EG muſt alſo be as perfectly cylindrical as poſſible. The part HBCDI is filled with mercury, having a vacuum above in AB. IF is filled with a light fluid, and FG with another light fluid which will not mix with that in IF. The ciſtern G is of the ſame diameter as AB. It is eaſy to ſee that the range of the ſeparating ſurface at F muſt be as much greater than that of the ſurface I as the area of I is greater than that of F. And this ratio is in our choice. This barometer is free from all the bad qualities of thoſe formerly deſcribed, being moſt delicately moveable; and is by far the fitteſt for a chamber, for amuſement, by obſervations on the changes of the atmoſpheric preſſure. The ſlighteſt breeze cauſes it to riſe and fall, and it is continually in motion.

279 Inferior to the common one for the meaſurement of heights.

But this, and all other contrivances of the kind, are inferior to the common barometer for meaſurement of heights, on account of their bulk and cumberſomeneſs: nay, they are inferior for all philoſophical purpoſes in point of accuracy; and this for a reaſon that admits of no reply. Their ſcale muſt be determined in all its parts by the common barometer; and, therefore, notwithſtanding their great range, they are ſuſceptible of no greater accuracy than that with which the ſcale of a common barometer can be obſerved and meaſured. This will be evident to any perſon who will take the trouble to conſider how the points of their ſcale muſt be aſcertained. The moſt accurate method for graduating ſuch a barometer as we have now deſcribed would be to make a mixture of vitriolic acid and water, which ſhould have $\frac{1}{10}$ of the denſity of mercury. Then, let a long tube ſtand vertical in this fluid, and connect its upper end with the open end of the barometer by a pipe which has a branch to which we can apply the mouth. Then if we ſuck through this pipe, the fluid will riſe both in the barometer and in the other tube; and 10 inches riſe in this tube will correſpond to one inch deſcent in the common barometer. In this manner may every point of the ſcale be adjuſted in due proportion to the reſt. But it ſtill remains to determine what particular point of the ſcale correſponds to ſome determined inch of the common barometer. This can only be done by an actual compariſon; and this being done, the whole becomes equally accurate. Except therefore for the mere purpoſe of chamber amuſement, in which caſe the barometer laſt deſcribed has a decided preference, the common barometer is to be preferred; and our attention ſhould be entirely directed to its improvement and portability.

280 How the common one might be improved.

For this purpoſe it ſhould be furniſhed with two microſcopes or magnifying glaſſes, one of them ſtationed at the beginning of the ſcale; which ſhould either be moveable, ſo that it may always be brought to the ſurface of the mercury in the ciſtern, or the ciſtern ſhould be ſo contrived that its ſurface may always be brought to the beginning of the ſcale. The glaſs will enable us to ſee the coincidence with accuracy. The other microſcope muſt be moveable, ſo as to be ſet oppoſite to the ſurface of the mercury in the tube; and the ſcale ſhould be furniſhed with a vernier which divides an inch into 1000 parts, and be made of materials of which we know the expanſion with great preciſion.

281 For an account of many ingenious contrivances to the make inſtruments accurate, portable, and commodious, conſult Magellan, *Diſſer. de diverſes Inſtr. de Phyſ.*; *Phil. Tranſ.* lxvii. lxviii. *Journ. de Phyſ.* xix. 108. 346. xvi. 392. xviii. 391. xxi. 436. xxii. 390.; Sulzer, *Act. Helvet.* iii. 259.; De Luc, *Recherches ſur les Modifications de l' Atmoſphere*, i. 401. ii. 459, 490. De Luc's ſeems the moſt ſimple and perfect of them all. Cardinal de Luynes (*Mem. Par.* 1768); Prinſ. De Luc, *Recherches*, § 63.; Van Swinden's *Poſitiones Phyſicæ*; *Com. Acad. Petrop.* i.; *Com. Acad. Petrop. Nov.* ii. 200 viii.

THUS we have given an elementary account of the diſtinguiſhing properties of air as a heavy and compreſſible fluid, and of the general phenomena which are immediate conſequences of theſe properties. This we have done in a ſet of propoſitions analogous to thoſe which form the doctrines of hydroſtatics. It remains to conſider it in another point of view, namely, as moveable and inert. The phenomena conſequent on theſe properties are exhibited in the velocities which air acquires by preſſure, in the reſiſtance which bodies meet with to their motion through the air, and in the impreſſion which air in motion gives to bodies expoſed to its action.

We ſhall firſt conſider the motions of which air is ſuſceptible when the equilibrium of preſſure (whether ariſing from its weight or its elaſticity) is removed; and, in the next place, we ſhall conſider its action on ſolid bodies expoſed to its current, and the reſiſtance which it makes to their motion through it.

282 Doctrine of air in acceſſible ſituations as acted on by equal and parallel gravity,

In this conſideration we ſhall avoid the extreme of generality, which renders the diſcuſſion too abſtract and difficult, and adapt our inveſtigation to the circumſtances in which compreſſible fluids (of which air is taken for the repreſentative) are moſt commonly found. We ſhall conſider air therefore as it is commonly found in acceſſible ſituations, as acted on by equal and parallel gravity; and we ſhall conſider it in the ſame order in which water is treated in a ſyſtem of hydraulics.

283 analogous to the doctrine of water in hydraulics.

In that ſcience the leading problem is to determine with what velocity the water will move through a given orifice when impelled by ſome known preſſure; and it has been found, that the beſt form in which this moſt difficult and intricate propoſition can be put, is to determine the velocity of water flowing through this orifice when impelled by its weight alone. Having determined this, we can reduce to this caſe every queſtion which can be propoſed; for, in place of the preſſure of any piſton or other mover, we can always ſubſtitute a perpendicular column of water or air whoſe weight ſhall be equal to the given preſſure.

284 The velocity with which air ruſhes into a void by its own weight,

The firſt problem, therefore, is to determine with what velocity air will ruſh into a void when impelled by its weight alone. This is evidently analogous to the hydraulic problem of water flowing out of a veſſel.

And here we muſt be contented with referring our readers to the ſolutions which have been given of that problem,

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problem, and the demonstration that it flows with the velocity which a heavy body would acquire by falling from a height equal to the depth of the hole under the surface of the water in the vessel. In whatever way we attempt to demonstrate that proposition, every step, nay, every word, of the demonstration applies equally to the air, or to any fluid whatever. Or, if our readers should wish to see the connection or analogy of the cases, we only desire them to recollect an undoubted maxim in the science of motion, that *when the moving force and the matter to be moved vary in the same proportion, the velocity will be the same.* If therefore there be similar vessels of air, water, oil, or any other fluid, all of the height of a homogeneous atmosphere, they will all run through equal and similar holes with the same velocity; for in whatever proportion the quantity of matter moving through the hole be varied by a variation of density, the pressure which forces it out, by acting in circumstances perfectly similar, varies in the same proportion by the same variation of density.

We must therefore assume it as the leading proposition, that *air rushes from the atmosphere into a void with the velocity which a heavy body would acquire by falling from the top of a homogeneous atmosphere.*

It is known that air is about 840 times lighter than water, and that the pressure of the atmosphere supports water at the height of 33 feet nearly. The height therefore of a homogeneous atmosphere is nearly 33×840, or 27720 feet. Moreover, to know the velocity acquired by any fall, recollect that a heavy body by falling one foot acquires the velocity of 8 feet per second; and that the velocities acquired by falling through different heights are as the square roots of the heights. Therefore to find the velocity corresponding to any height, expressed in feet per second, multiply the square root of the height by 8. We have therefore in the present instance $V = \sqrt{27220}, = 8 \times 166.493, = 1332$ feet per second. This therefore is the velocity with which common air will rush into a void; and this may be taken as a standard number in pneumatics, as 16 and 32 are standard numbers in the general science of mechanics, expressing the action of gravity at the surface of the earth.

It is easy to see that greater precision is not necessary in this matter. The height of a homogeneous atmosphere is a variable thing, depending on the temperature of the air. If this reason seems any objection against the use of the number 1332, we may retain $8\sqrt{H}$ in place of it, where H expresses the height of a homogeneous atmosphere of the given temperature. A variation of the barometer makes no change in the velocity, nor in the height of the homogeneous atmosphere, because it is accompanied by a proportional variation in the density of the air. When it is increased $\frac{1}{10}$, for instance, the density is also increased $\frac{1}{10}$; and thus the expelling force and the matter to be moved are changed in the same proportion, and the velocity remains the same. N. B. We do not here consider the velocity which the air acquires after its issuing into the void by its continual expansion. This may be ascertained by the 39th prop. of Newton's *Principia*, b. i. Nay, which appears very paradoxical, if a cylinder of air, communicating in this manner with a void, be compressed by a piston loaded with a weight, which presses it down as the air flows out, and thus keeps it of the same density, the velocity of efflux will still be the same, however great the pressure may chance to be: for the first and immediate effect of the load on the piston is to reduce the air in the cylinder to such a density that its elasticity shall exactly balance the load; and because the elasticity of air is proportional to its density, the density of the air will be increased in the same proportion with the load, that is, with the expelling power (for we are neglecting at present the weight of the included air as too inconsiderable to have any sensible effect). Therefore, since the matter to be moved is increased in the same proportion with the pressure, the velocity will be the same as before.

285 and the velocity with which it rushes into a space containing rarer air.

It is equally easy to determine the velocity with which the air of the atmosphere will rush into a space containing rarer air. Whatever may be the density of this air, its elasticity, which follows the proportion of its density, will balance a proportional part of the pressure of the atmosphere; and it is the excess of this last only which is the moving force. The matter to be moved is the same as before. Let D be the natural density of the air, and δ the density of the air contained in the vessel into which it is supposed to run, and let P be the pressure of the atmosphere, and therefore equal to the force which impels it into a void; and let π be the force with which this rarer air would run into a void. We have $D : \delta = P : \pi$, and $\pi = \frac{P\delta}{D}$. Now the moving force in the present instance is $P - \pi$, or $P - \frac{P\delta}{D}$. Lastly, let V be the velocity of air rushing into a void, and v the velocity with which it will rush into this rarefied air.

It is a theorem in the motion of fluids, that the pressures are as the squares of the velocities of efflux. Therefore $P : P - \frac{P\delta}{D} = V^2 : v^2$. Hence we derive $v^2 = V^2 \times \overline{1 - \frac{\delta}{D}}$, and $v \times V = \sqrt{\overline{1 - \frac{\delta}{D}}}$. We do not here consider the resistance which the air of the atmosphere will meet with from the inertia of that in the vessel which it must displace in its motion.

Here we see that there will always be a current into the vessel while δ is less than D.

We also learn the gradual diminution of the velocity as the vessel fills; for δ continually increases, and therefore $1 - \frac{\delta}{D}$ continually diminishes.

It remains to determine the time t expressed in seconds, in which the air of the atmosphere will flow into this vessel from its state of vacuity till the air in the vessel has acquired any proposed density δ.

For this purpose let H, expressed in feet, be the height through which a heavy body must fall in order to acquire the velocity V, expressed also in feet per second. This we shall express more briefly in future, by calling it the height producing the velocity V. Let C represent the capacity of the vessel, expressed in cubic feet, and O the area or section of the orifice, expressed in superficial or square feet; and let the natural density of the air be D.

Since the quantity of aerial matter contained in a vessel depends on the capacity of the vessel and the density of the air jointly, we may express the air which would

would fill this veſſel by the ſymbol CD when the air is in its ordinary ſtate, and by $C\delta$ when it has the denſity δ. In order to obtain the rate at which it fills, we muſt take the fluxion of this quantity $C\delta$. This is $C\dot{\delta}$; for C is a conſtant quantity, and δ is a variable or flowing quantity.

But we alſo obtain the rate of influx by our knowledge of the velocity, and the area of the orifice, and the denſity. The velocity is V, or $8\sqrt{H}$, at the firſt inſtant; and when the air in the veſſel has acquired the denſity δ, that is, at the end of the time t, the velocity is $8\sqrt{H}\sqrt{1-\frac{\delta}{D}}$, or $8\sqrt{H}\sqrt{\frac{D-\delta}{D}}$,

or $8\sqrt{H}\frac{\sqrt{D-\delta}}{\sqrt{D}}$.

The rate of influx therefore (which may be conceived as meaſured by the little maſs of air which will enter during the time $\dot{t}$ with this velocity) will be $\frac{8\sqrt{HOD}\sqrt{D-\delta}\,\dot{t}}{\sqrt{D}}$, or $8\sqrt{HO}\sqrt{D}\sqrt{D-\delta}\,\dot{t}$, multiplying the velocity by the orifice and the denſity.

Here then we have two values of the rate of influx. By ſtating them as equal we have a fluxionary equation, from which we may obtain the fluents, that is, the time t in ſeconds neceſſary for bringing the air in the veſſel to the denſity δ, or the denſity δ which will be produced at the end of any time t. We have the equation $8\sqrt{HO}\sqrt{D}\sqrt{D-\delta}\,\dot{t}=C\dot{\delta}$. Hence we derive $\dot{t}=\frac{C}{8\sqrt{HO}\sqrt{D}}\times\frac{\dot{\delta}}{\sqrt{D-\delta}}$. Of this the fluent is $t=\frac{C}{4\sqrt{HO}\sqrt{D}}\times\sqrt{D-\delta}+A$, in which A is a conditional conſtant quantity. The condition which determines it is, that t muſt be nothing when δ is nothing, that is, when $\sqrt{D-\delta}=\sqrt{D}$; for this is evidently the caſe at the beginning of the motion. Hence it follows, that the conſtant quantity is $\sqrt{D}$, and the complete fluent, ſuited to the caſe, is

$$\frac{C}{4\sqrt{HO}\sqrt{D}}\times\overline{\sqrt{D}-\sqrt{D-\delta}}.$$

The motion ceaſes when the air in the veſſel has acquired the denſity of the external air; that is, when $\delta=D$, or when $t=\frac{C}{4\sqrt{HO}\sqrt{D}}\times\sqrt{D}, =\frac{C}{4\sqrt{HO}}$. Therefore the time of completely filling the veſſel is $\frac{C}{4\sqrt{HO}}$.

286 Illuſtrated by examples in numbers.

Let us illuſtrate this by an example in numbers.

Suppoſing then that air is 840 times lighter than water, and the height of the homogeneous atmoſphere 27720 feet, we have $4\sqrt{H}=666$. Let us further ſuppoſe the veſſel to contain 8 cubic feet, which is nearly a wine hogſhead, and that the hole by which the air of the ordinary denſity, which we ſhall make $=1$, enters is an inch ſquare, or $\frac{1}{144}$ of a ſquare foot. Then the time in ſeconds of completely filling it will be $\frac{8'}{\frac{1}{144}666}$, or $\frac{1152''}{666}$, or 1.7297″ If the hole is only $\frac{1}{100}$ of a ſquare inch, that is, if its ſide is $\frac{1}{10}$ of an inch, the time of completely filling the hogſhead will be 173″ very nearly, or ſomething leſs than three minutes.

If we make the experiment with a hole cut in a thin plate, we ſhall find the time greater nearly in the proportion of 63 to 100, for reaſons obvious to all who have ſtudied hydraulics. In like manner we can tell the time neceſſary for bringing the air in the veſſel to $\frac{3}{4}$ of its ordinary denſity. The only variable part of our fluent is the coefficient $-\sqrt{D-\delta}$, or $\sqrt{1-\delta}$. Let δ be $=\frac{3}{4}$, then $\sqrt{1-\delta}=\sqrt{\frac{1}{4}}=\frac{1}{2}$, and $1-\sqrt{1-\delta}=\frac{1}{2}$; and the time is $86\frac{1}{2}''$ very nearly when the hole is $\frac{1}{10}$ of an inch wide.

Fig. 81. 287 The velocity of air with the additional impulſe of a weight moving down the veſſel.

Let us now ſuppoſe that the air in the veſſel ABCD (fig. 81.) is compreſſed by a weight acting on the cover AD, which is moveable down the veſſel, and is thus expelled into the external air.

The immediate effect of this external preſſure is to compreſs the air and give it another denſity. The denſity D of the external air correſponds to its preſſure P. Let the additional preſſure on the cover of the veſſel be p, and the denſity of the air in the veſſel be d. We ſhall have $P : P+p=D : d$; and therefore $p=P\times\frac{d-D}{D}$. Then, becauſe the preſſure which expels the air is the difference between the force which compreſſes the air in the veſſel and the force which compreſſes the external air, the expelling force is p. And becauſe the quantities of motion are as the forces which ſimilarly produce them, we ſhall have $P : P\times\frac{d-D}{D}=MV : mv$; where M and m expreſs the quantities of matter expelled, V expreſſes the velocity with which air ruſhes into a void, and v expreſſes the velocity ſought. But becauſe the quantities of aerial matter which iſſue from the ſame orifice in a moment are as the denſities and velocities jointly, we ſhall have $MV : mv=DVV : dvv, =DV^2 : dv^2$. Therefore $P : p\frac{d-D}{D}=DV^2 : dv$. Hence we deduce $v=V\sqrt{\frac{d-D}{d}}$.

We may have another expreſſion of the velocity without conſidering the denſity. We had $P : P+p=D : d$: therefore $d=\frac{D\times\overline{P+p}}{P}$, and $d-D=\frac{D\times\overline{P+p}}{P}-D$, $=\frac{D\times\overline{P+p}-DP}{P}$, and $\frac{d-D}{d}=\frac{D\times\overline{P+p}-DP}{D\times\overline{P+p}}, =\frac{P+p-P}{P+p}, =\frac{p}{P+p}$: therefore $v=V\times\sqrt{\frac{p}{P+p}}$, which is a very ſimple and convenient expreſſion.

288 The effect of the air's elaſticity conſidered. Fig. 81.

Hitherto we have conſidered the motion of air as produced by its weight only. Let us now conſider the effect of its elaſticity.

Let ABCD (fig. 81.) be a veſſel containing air of any denſity D. This air is in a ſtate of compreſſion; and if the compreſſing force be removed, it will expand, and its elaſticity will diminiſh along with its denſity. Its elaſticity in any ſtate is meaſured by the force which keeps it in that ſtate. The force which keeps common air in its ordinary denſity is the weight of the atmoſphere, and is the ſame with the weight of a column of water 33 feet high. If therefore we ſuppoſe that this air,

air, instead of being confined by the top of the vessel, is pressed down by a moveable piston carrying a column of water 33 feet high, its elasticity will balance this pressure as it balances the pressure of the atmosphere; and as it is a fluid, and propagates through every part the pressure exerted on any one part, it will press on any little portion of the vessel by its elasticity in the same manner as when loaded with this column.

The consequence of this reasoning is, that if this small portion of the vessel be removed, and thus a passage be made into a void, the air will begin to flow out with the same velocity with which it would flow when impelled by its weight alone, or with the velocity acquired by falling from the top of a homogeneous atmosphere, or 1332 feet in a second nearly.

But as soon as some air has come out, the density of the remaining air is diminished, and its elasticity is diminished; therefore the expelling force is diminished. But the matter to be moved is diminished in the very same proportion, because the density and elasticity are found to vary according to the same law; therefore the velocity will continue the same from the beginning to the end of the efflux.

This may be seen in another way. Let P be the pressure of the atmosphere, which being the counterbalance and measure of the initial elasticity, is equal to the expelling force at the first instant. Let D be the initial density, and V the initial velocity. Let d be its density at the end of the time t of efflux, and v the contemporaneous velocity. It is plain that at the end of this time we shall have the expelling force $\pi = \frac{Pd}{D}$; for $D : d = P : \pi \left(= \frac{Pd}{D}\right)$.

These forces are proportional to the quantities of motion which they produce; and the quantities of motion are proportional to the quantities of matter M and m and the velocities V and v jointly: therefore we have $P : \frac{Pd}{D} = MV : mv$. But the quantities of matter which escape through a given orifice are as the densities and velocities jointly; that is, $M : m = DV : dv$: therefore $P : \frac{Pd}{D} = DV^2 : dv^2$, and $P \times dv^2 = \frac{PdDV^2}{D} = PdV^2$, and $V^2 = v^2$, and $V = v$, and the velocity of efflux is constant. Hence follows, what appears very unlikely at first sight, that however much the air in the vessel is condensed, it will always issue into a void with the same velocity.

289 Quantity of air issuing into a void in a given time, and the density at the end of that time.

In order to find the quantity of aerial matter which will issue during any time t, and consequently the density of the remaining air at the end of this time, we must get the rate of efflux. In the element of time $\dot{t}$ there issues (by what has been said above) the bulk $8\sqrt{HO}\,\dot{t}$ (for the velocity V is constant); and therefore the quantity $8\sqrt{HO}\,d\dot{t}$. On the other hand, the quantity of air at the beginning was CD, C being the capacity of the vessel; and when the air has acquired the density d, the quantity is Cd, and the quantity run out is $CD - Cd$: therefore the quantity which has run out in the time $\dot{t}$ must be the fluxion of $CD - Cd$, or $-C\dot{d}$. Therefore we have the equation $8\sqrt{HO}\,d\dot{t} = -C\dot{d}$, and $\dot{t} = \frac{-C\dot{d}}{8\sqrt{HO}\,d}, = \frac{C}{8\sqrt{HO}} \times -\frac{\dot{d}}{d}$.

The fluent of this is $t = \frac{C}{8\sqrt{HO}}$ log. d. This fluent must be so taken that t may be $= o$ when $d = D$. Therefore the correct fluent will be $t = \frac{C}{8\sqrt{HO}}$ log. $\frac{D}{d}$, for log. $\frac{D}{D} =$ log. 1, $= o$. We deduce from this, that it requires an infinite time for the whole air of a vessel to flow out of it into a void. N. B. By log. d, &c. is meant the hyperbolic logarithm of d, &c.

Let us next suppose that the vessel, instead of letting out its air into a void, emits it into air of a less density, which remains constant during the efflux, as we may suppose to be the case when a vessel containing condensed air emits it into the surrounding atmosphere. Let the initial density of the air in the vessel be δ, and that of the atmosphere D. Then it is plain that the expelling force is $P - \frac{PD}{\delta}$, and that after the time t it is $\frac{Pd}{\delta} - \frac{PD}{\delta}$. We have therefore $P - \frac{PD}{\delta} : \frac{Pd}{\delta} - \frac{PD}{\delta} = MV : mv, = \delta V^2 : dv^2$. Whence we derive $v = V\sqrt{\frac{\delta\,\overline{d-D}}{d\,\overline{\delta-D}}}$. 290 When the vessel emits it into rarer air.

From this equation we learn that the motion will be at an end when $d = D$: and if $\delta = D$ there can be no efflux.

291 Relation between the time and density when issuing into a void.

To find the relation between the time and the density, let H as before be the height producing the velocity V. The height producing the velocity of efflux v must be $H \times \frac{\delta\,\overline{d-D}}{d\,\overline{\delta-D}}$, and the little parcel of air which will flow out in the time $\dot{t}$ will be $= 8\sqrt{HO}\,d\dot{t}\sqrt{\frac{\delta\,\overline{d-D}}{d\,\overline{\delta-D}}}$. On the other hand, it is $= -C\dot{d}$.

Hence we deduce the fluxionary equation $\dot{t} = \frac{C\sqrt{\delta - D}}{8\sqrt{HO\sqrt{\delta}}} \times \frac{-\dot{d}}{\sqrt{d^2 - Dd}}$. The fluent of this, corrected so as to make $t = O$ when $d = \delta$, is $t = \frac{C\sqrt{\delta - D}}{8\sqrt{HO}\sqrt{\delta}} \times$ log. $\left(\frac{\delta - \frac{1}{2}D + \sqrt{\delta^2 - D\delta}}{d - \frac{1}{2}D + \sqrt{d^2 - Dd}}\right)$. And the time of completing the efflux, when $d = D$, is $\dot{t} = \frac{C\sqrt{\delta - D}}{8\sqrt{HO}\sqrt{\delta}} \times$ log. $\left(\frac{\delta - \frac{1}{2}D + \sqrt{\delta^2 - D\delta}}{\frac{1}{2}D}\right)$.

Fig. 82. 292 When issuing from denser into rarer air.

Lastly, let ABCD, CFGH (fig. 82.) be two vessels containing airs of different densities, and communicating by the orifice C, there will be a current from the vessel containing the denser air into that containing the rarer: suppose from ABCD into CFGH.

Let P be the elastic force of the air in ABCD, Q its density, and V its velocity, and D the density of the air in CFGH. And, after the time t, let the density of

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of the air in ABCD be q, its velocity v, and the density of the air in CFGH be δ. The expelling force from ABCD will be $P - \frac{PD}{Q}$ at the firſt inſtant, and at the end of the time t it will be $\frac{Pq}{Q} - \frac{P\delta}{Q}$. Therefore we ſhall have $P - \frac{PD}{Q} : \frac{Pq}{Q} - \frac{P\delta}{Q} = QV^2 : qv^2$, which gives $v = V \times \sqrt{\frac{Q(q-\delta)}{q(Q-D)}}$, and the motion will ceaſe when $\delta = q$.

Let A be the capacity of the firſt veſſel, and B that of the ſecond. We have the ſecond equation $AQ + BD = Aq + B\delta$, and therefore $\delta = \frac{A(Q-q) + BD}{B}$. Subſtituting this value of δ in the former value of v, we have $v = \times \sqrt{\frac{Q[B(q-D) - A(Q-q)]}{qB(Q-D)}}$, which gives the relation between the velocity v and the denſity q.

In order to aſcertain the time when the air in ABCD has acquired the denſity q, it will be convenient to abridge the work by ſome ſubſtitutions. Therefore make $Q(B+A) = M$, $BQD + BQ^2 = N$, $BQ - BD = R$ and $\frac{N}{M} = m$. Then, proceeding as before, we obtain the fluxionary equation $8\sqrt{HO}\, q \frac{\sqrt{Mq-N}}{\sqrt{R}\sqrt{q}} \dot{t} = \overline{AQ - Aq}^{\,\cdot} = -A\dot{q}$, whence $\dot{t} = \frac{A\sqrt{R}}{8\sqrt{HO}\sqrt{M}} \times \frac{\dot{q}}{\sqrt{q^2 - mq}}$ of which the fluent, completed ſo that $t = o$ when $q = Q$, is $t = \frac{A\sqrt{R}}{8\sqrt{HO}\sqrt{M}} \times \log.\left(\frac{Q - \frac{1}{2}m + \sqrt{(Q^2 mQ)}}{q - \frac{1}{2}m + \sqrt{(q^2 mq)}}\right)$.

293 When air is expelled by force, as in bellows.

Some of theſe queſtions are of difficult ſolution, and they are not of frequent uſe in the more important and uſual applications of the doctrines of pneumatics, at leaſt in their preſent form. The caſes of greateſt uſe are when the air is expelled from a veſſel by an external force, as when bellows are worked, whether of the ordinary form or conſiſting of a cylinder fitted with a moveable piſton. This laſt caſe merits a particular conſideration; and, fortunately, the inveſtigation is extremely eaſy.

Fig. 81.

Let AD fig. 81. be conſidered as a piſton moving downward with the uniform velocity f, and let the area of the piſton be n times the area of the hole of efflux, then the velocity of efflux ariſing from the motion of the piſton will be nf. Add this to the velocity V produced by the elaſticity of the air in the firſt queſtion, and the whole velocity will be $V + nf$. It will be the ſame in the other. The problem is alſo freed from the conſideration of the time of efflux. For this depends now on the velocity of the piſton. It is ſtill, however, a very intricate problem to aſcertain the relation between the time and the denſity, even though the piſton is moving uniformly; for at the beginning of the motion the air is of common denſity. As the piſton deſcends, it both expels and compreſſes the air, and the denſity of the air in the veſſel varies in a very intricate manner, as alſo its reſiſtance or reaction on the piſton. For this reaſon, a piſton which moves uniformly by means of an external force will never make an uniform blaſt by ſucceſſive ſtrokes; it will always be weaker at the beginning of the ſtroke. The beſt way for ſecuring an uniform blaſt is to employ the external force only for lifting up the piſton, and then to let the piſton deſcend by its own weight. In this way it will quickly ſink down, compreſſing the air, till its denſity and correſponding elaſticity exactly balance the weight of the piſton. After this the piſton will deſcend equably, and the blaſt will be uniform. We ſhall have occaſion to conſider this more particularly under the head of *PNEUMATICAL Machines*. Theſe obſervations and theorems will ſerve to determine the initial velocity of the air in all important caſes of its expulſion. The philoſopher will learn the rate of its efflux out of one veſſel into another; the chemiſt will be able to calculate the quantities of the different gaſes which are employed in the curious experiments of the ingenious but unfortunate Lavoiſier on Combuſtion, and will find them extremely different from what he ſuppoſed; the engineer will learn how to proportion the motive force of his machine to the quantity of aerial matter which his bellows muſt ſupply. But it is not enough, for this purpoſe, that the air *begin* to iſſue in the proper quantity; we muſt ſee whether it be not affected by the circumſtances of its ſubſequent paſſage.

294 Paſſage of air through pipes, &c. ſimilar to the motion of water in conduits.

All the modifications of motion which are obſerved in water conduits take place alſo in the paſſage of air through pipes and holes of all kinds. There is the ſame diminution of quantity paſſing through a hole in a thin plate that is obſerved in water. We know that (abating the ſmall effect of friction) water iſſues with the velocity acquired by falling from the ſurface; and yet if we calculate by this velocity and by the area of the orifice, we ſhall find the quantity of water deficient nearly in the proportion of 63 to 100. This is owing to the water preſſing towards the orifice from all ſides, which occaſions a contraction of the jet. The ſame thing happens in the efflux of air. Alſo the motion of water is greatly impeded by all contractions of its paſſage. Theſe oblige it to accelerate its velocity, and therefore require an increaſe of preſſure to force it through them, and this in proportion to the ſquares of the velocities. Thus, if a machine working a pump cauſes it to give a certain number of ſtrokes in a minute, it will deliver a determined quantity of water in that time. Should it happen that the paſſage of the water is contracted to one half in any part of the machine (a thing which frequently happens at the valves), the water muſt move through this contraction with twice the velocity that it has in the reſt of the paſſage. This will require four times the force to be exerted on the piſton. Nay (which will appear very odd, and is never ſuſpected by engineers), if no part of the paſſage is narrower than the barrel of the pump, but on the contrary a part much wider, and if the conduit be again contracted to the width of the barrel, an additional force muſt be applied to the piſton to drive the water through this paſſage, which would not have been neceſſary if the paſſage had not been widened in any part. It will require a force equal to the weight of a column of water of the height neceſſary for communicating a velocity, the ſquare of which is equal to the difference of the ſquares of the velocities of the water in the wide and the narrow part of the conduit.

The

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The fame thing takes place in the motion of air, and therefore all contractions and dilatations muft be carefully avoided, when we want to preferve the velocity unimpaired.

295 Air fuffers the fame retardation along pipes as water, and the neceffity of attending to this.

Air alfo fuffers the fame retardation in its motion along pipes. By not knowing, or not attending to that, engineers of the firft reputation have been prodigioufly difappointed in their expectations of the quantity of air which will be delivered by long pipes. Its extreme mobility and lightnefs hindered them from fufpecting that it would fuffer any fenfible retardation. Dr Papin, a moft ingenious man, propofed this as the moft effectual method of transferring the action of a moving power to a great diftance. Suppofe, for inftance, that it was required to raife water out of a mine by a water-machine, and that there was no fall of water nearer than a mile's diftance. He employed this water to drive a pifton, which fhould comprefs the air in a cylinder communicating, by a long pipe, with another cylinder at the mouth of the mine. This fecond cylinder had a pifton in it, whofe rod was to give motion to the pumps at the mine. He expected, that as foon as the pifton at the water-machine had compreffed the air fufficiently, it would caufe the air in the cylinder at the mine to force up its pifton, and thus work the pumps. Dr Hooke made many objections to the method, when laid before the Royal Society, and it was much debated there. But dynamics was at this time an infant fcience, and very little underftood. Newton had not then taken any part in the bufinefs of the fociety, otherwife the true objections would not have efcaped his fagacious mind. Notwithftanding Papin's great reputation as an engineer and mechanic, he could not bring his fcheme into ufe in England; but afterwards, in France and in Germany, where he fettled, he got fome perfons of great fortunes to employ him in this project; and he erected great machines in Auvergne and Weftphalia for draining mines. But, fo far from being effective machines, they would not even begin to move. He attributed the failure to the quantity of air in the pipe of communication, which muft be condenfed before it can condenfe the air in the remote cylinder. This indeed is true, and he fhould have thought of this earlier. He therefore diminifhed the fize of this pipe, and made his water-machine exhauft inftead of condenfing, and had no doubt but that the immenfe velocity with which air rufhes into a void would make a rapid and effectual communication of power. But he was equally difappointed here, and the machine at the mine ftood ftill as before.

Near a century after this, a very intelligent engineer attempted a much more feafible thing of this kind at an iron-foundery in Wales. He erected a machine at a powerful fall of water, which worked a fet of cylinder bellows, the blowpipe of which was conducted to the diftance of a mile and a half, where it was applied to a blaft furnace. But notwithftanding every care to make the conducting pipe very air-tight, of great fize, and as fmooth as poffible, it would hardly blow out a candle. The failure was afcribed to the impoffibility of making the pipe air-tight. But, what was furprifing, above ten minutes elapfed after the action of the piftons in the bellows before the leaft wind could be perceived at the end of the pipe; whereas the engineer expected an interval of 6 feconds only.

295 No diftinct theory on this fubject.

No very diftinct theory can be delivered on this fubject; but we may derive confiderable affiftance in underftanding the caufes of the obftruction to the motion of water in long pipes, by confidering what happens to air. The elafticity of the air, and its great compreffibility, have given us the diftincteft notions of fluidity in general, fhowing us, in a way that can hardly be controverted, that the particles of a fluid are kept at a diftance from each other, and from other bodies, by the corpufcular forces. We fhall therefore take this opportunity to give a view of the fubject, which did not occur to us when treating of the motion of water in pipes, referving a further difcuffion to the articles RIVER, *WATER-Works*.

296 How fluids are obftructed in moving along canals.

The writers on hydrodynamics have always confidered the obftruction to the motion of fluids along canals of any kind, as owing to fomething like the friction by which the motion of folid bodies on each other is obftructed; but we cannot form to ourfelves any diftinct notion of refemblance, or even analogy between them. The fact is, however, that a fluid running along a canal has its motion obftructed; and that this obftruction is greateft in the immediate vicinity of the folid canal, and gradually diminifhes to the middle of the ftream. It appears, therefore, that the parts of fluids can no more move among each other than among folid bodies, without fuffering a diminution of their motion. The parts in phyfical contact with the fides and bottom are retarded by thefe immoveable bodies. The particles of the next ftratum of fluid cannot preferve their initial velocities without overpaffing the particles of the firft ftratum; and it appears from the fact that they are by this means retarded. They retard in the fame manner the particles of the third ftratum, and fo on to the middle ftratum or thread of fluid. It appears from the fact, therefore, that this fort of friction is not a confequence of rigidity alone, but that it is equally competent to fluids. Nay, fince it is a matter of fact in air, and is even more remarkable there than in any other fluid, as we fhall fee by the experiments which have been made on the fubject; and as our experiments on the compreffion of air fhow us the particles of air ten times nearer to each other in fome cafes than in others (viz. when we fee air a thoufand times denfer in thefe cafes), and therefore force us to acknowledge that they are not in contact; it is plain that this obftruction has no analogy to friction, which fuppofes roughnefs or inequality of furface. No fuch inequality can be fuppofed in the furface of an aerial particle; nor would it be of any fervice in explaining the obftruction, fince the particles do not rub on each other, but pafs each other at fome fmall and imperceptible diftance.

We muft therefore have recourfe to fome other mode of explication. We fhall apply this to air only in this place; and, fince it is proved by the incontrovertible experiments of Canton, Zimmerman, and others, that water, mercury, oil, &c. are alfo compreffible and perfectly elaftic, the argument from this principle, which is conclufive in air, muft equally explain the fimilar phenomenon in hydraulics.

The moft highly polifhed body which we know muft be conceived as having an uneven furface when we compare it with the fmall fpaces in which the corpufcular forces are exerted; and a quantity of air moving

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in a polished pipe may be compared to a quantity of small shot sliding down a channel with undulated sides and bottom. The row of particles immediately contiguous to the sides will therefore have an undulated motion: but this undulation of the contiguous particles of air will not be so great as that of the surface along which they glide; for not only every motion requires force to produce it, but also every change of motion. The particles of air resist this change from a rectilineal to an undulating motion; and, being elastic, that is, repelling each other and other bodies, they keep a little nearer to the surface as they are passing over an eminence, and their path is less incurvated than the surface. The difference between the motion of the particles of air and the particles of a fluid quite unelastic is, in this respect, somewhat like the difference between the motion of a spring-carriage and that of a common carriage. When the common carriage passes along a road not perfectly smooth, the line described by the centre of gravity of the carriage keeps perfectly parallel to that described by the axis of the wheels, rising and falling along with it. Now let a spring body be put on the same wheels and pass along the same road. When the axis rises over an eminence perhaps half an inch, sinks down again into the next hollow, and then rises a second time, and so on, the centre of gravity of the body describes a much straighter line; for upon the rising of the wheels, the body resists the motion, and compresses the springs, and thus remains lower than it would have been had the springs not been interposed. In like manner, it does not sink so low as the axle does when the wheels go into a hollow. And thus the motion of spring-carriages becomes less violently undulated than the road along which they pass. This illustration will, we hope, enable the reader to conceive how the deviation of the particles next to the sides and bottom of the canal from a rectilineal motion is less than that of the canal itself.

297 Particles of air resist a change from a rectilineal to an undulating motion,

298 and the undulation of the second row of particles will be less than that of the first. Fig. 83.

It is evident that the same reasoning will prove that the undulation of the next row of particles will be less than that of the first, that the undulation of the third row will be less than that of the second, and so on, as is represented in fig. 83. And thus it appears, that while the mass of air has a progressive motion along the pipe or canal, each particle is describing a waving line, of which a line parallel to the direction of the canal is the axis, cutting all these undulations. This axis of each undulated path will be straight or curved as the canal is, and the excursions of the path on each side of its axis will be less and less as the axis of the path is nearer to the axis of the canal.

299 Each particle appears to lose no velocity.

Let us now see what *sensible* effect this will have; for all the motion which we here speak of is imperceptible. It is demonstrated in mechanics, that if a body moving with any velocity be deflected from its rectilineal path by a curved and perfectly smooth channel, to which the rectilineal path is a tangent, it will proceed along this channel with undiminished velocity. Now the path, in the present case, may be considered as perfectly smooth, since the particles do not touch it. It is one of the undulations which we are considering, and we may at present conceive this as without any subordinate inequalities. There should not, therefore, be any diminution of the velocity. Let us grant this of the absolute velocity of the particle; but what we observe is the velocity of the mass, and we judge of it perhaps by the motion of a feather carried along by it. Let us suppose a single atom to be a sensible object, and let us attend to two such particles, one at the side, and the other in the middle: although we cannot perceive the undulations of these particles during their progressive motions, we see the progressive motions themselves. Let us suppose then that the middle particle has moved without any undulation whatever, and that it has advanced ten feet. The lateral particle will also have moved ten feet; but this has not been in a straight line. It will not be so far advanced, therefore, in the direction of the canal; it will be left behind, and will appear to us to have been retarded in its motion: and in like manner each thread of particles will be more and more retarded (apparently only) as it recedes farther from the axis of the canal, or what is usually called the thread of the stream.

300 But on the whole the undulatory motion is a real obstruction.

And thus the observed fact is shown to be a necessary consequence of what we know to be the nature of a compressible or elastic fluid; and that without supposing any diminution in the real velocity of each particle, there will be a diminution of the velocity of the sensible threads of the general stream, and a diminution of the whole quantity of air which passes along it during a given time.

Let us now suppose a parcel of air impelled along a pipe, which is *perfectly* smooth, out of a larger vessel, and issuing from this pipe with a certain velocity. It requires a certain force to change its velocity in the vessel to the greater velocity which it has in the pipe. This is abundantly demonstrated. How long soever we suppose this pipe, there will be no change in the velocity, or in the force to keep it up. But let us suppose that about the middle of this pipe there is a part of it which has suddenly got an undulated surface, however imperceptible. Let us further suppose that the final velocity of the middle thread is the same as before. In this case it is evident that the sum total of the motions of all the particles is greater than before, because the absolute motions of the lateral particles is greater than that of the central particle, which we suppose the same as before. This absolute increase of motion cannot be without an increase of propelling force: the force acting now, therefore, must be greater than the force acting formerly. Therefore, if only the former force had continued to act, the same motion of the central particle could not have been preserved, or the progressive motion of the whole stream must be diminished.

And thus we see that this internal insensible undulatory motion becomes a real obstruction to the sensible motion which we observe, and occasions an expence of power.

301 An additional force necessary for preserving a given progressive motion,

Let us see what will be the consequence of extending this obstructing surface further along the canal. It must evidently be accompanied by an augmentation of the motion produced, if the central velocity be still kept up; for the particles which are now in contact with the sides do not continue to occupy that situation: the middle particles moving faster *forward* get over them, and in their turn come next the side; and as they are really moving equally fast, but not in the direction into which they are now to be forced, force is necessary for changing the direction also; and this is in addition

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addition to the force necessary for producing the undulations so minutely treated of. The consequence of this must be, that an additional force will be necessary for preserving a given progressive motion in a longer *obstructing* pipe, and that the motion produced in a pipe of greater length by a given force will be less than in a shorter one, and the efflux will be diminished.

302 especially through any contraction.

There is another consideration which must have an influence here. Nothing is more irrefragably demonstrated than the necessity of an additional force for producing an efflux through any contraction, even though it should be succeeded by a dilatation of the passage. Now both the inequalities of the sides and the undulations of the motions of each particle are equivalent to a succession of contractions and dilatations; although each of these is next to infinitely small; their number is also next to infinitely great, and therefore the total effect may be sensible.

303 There are besides other obstructions, as angular asperities, &c.

We have hitherto supposed that the absolute velocity of the particles was not diminished: this we did, having assumed that the interval of each undulation of the sides was without inequalities. But this was gratuitous: it was also gratuitous that the sides were only undulated. We have no reason for excluding angular asperities. These will produce, and most certainly often produce, real diminutions in the velocity of the contiguous particles; and this must extend to the very axis of the canal, and produce a diminution of the sum total of motion: and in order to preserve the same sensible progressive motion, a greater force must be employed. This is all that can be meant by saying that there is a resistance to the motion of air through long pipes.

304 and a want of perfect fluidity.

There remains another cause of diminution, viz. the want of perfect fluidity, whether arising from the dissemination of solid particles in a real fluid, or from the viscidity of the fluid. We shall not insist on this at present, because it cannot be shown to obtain in air, at least in any case which deserves consideration. It seems of no importance to determine the motion of air hurrying along with it soot or dust. The effect of fogs on a particular modification of the motion of air will be considered under the article SOUND. What has been said on this subject is sufficient for our purpose, as explaining the prodigious and unexpected obstruction to the passage of air through long and narrow pipes. We are able to collect an important maxim from it, viz. that all pipes of communication should be made as wide as circumstances will permit; for it is plain that the obstruction depends on the internal surface, and the force to overcome it must be in proportion to the mass of matter which is in motion. The first increases as the diameter of the pipe, and the last as the square. The obstruction must therefore bear a greater proportion to the whole motion in a small pipe than in a large one.

305 The law of retardation extending from the axis to the sides of the canal unknown.

It were very desirable to know the law by which the retardation extends from the axis to the sides of the canal, and the proportion which subsists between the lengths of the canal and the forces necessary for overcoming the obstructions when the velocity is given; as also whether the proportion of the obstruction to the whole motion varies with the velocity: but all this is unknown. It does not, however, seem a desperate case in air: we know pretty distinctly the law of action among its particles, viz. that their mutual repulsions are inversely as their distances. This promises to enable us to trace the progress of undulation from the sides of the canal to the axis.

306 It will not increase so fast as the square of the velocities.

We can see that the retardations will not increase so fast as the square of the velocity. Were the fluid incompressible, so that the undulatory path of a particle were invariable, the deflecting forces by which each individual particle is made to describe its undulating path would be precisely such as arise from the path itself and the motion in it; for each particle would be in the situation of a body moving along a fixed path. But in a very compressible fluid, such as air, each particle may be considered as a solitary body, actuated by a projectile and a transverse force, arising from the action of the adjoining particles. Its motion must depend on the adjustment of these forces, in the same manner as the elliptical motion of a planet depends on the adjustment of the force of projection, with a gravitation inversely proportional to the square of the distance from the focus. The transverse force in the present case has its origin in the pressure on the air which is propelling it along the pipe: this, by squeezing the particles together, brings their mutual repulsion into action. Now it is the property of a perfect fluid, that a pressure exerted on any part of it is propagated equally through the whole fluid; therefore the transverse forces which are excited by this pressure are proportional to the pressure itself; and we know that the pressures exerted on the surface of a fluid, so as to expel it through any orifice, or along any canal, are proportional to the squares of the velocities which they produce. Therefore, in every point of the undulatory motion of any particle, the transverse force by which it is deflected into a curve is proportional to the square of its velocity. When this is the case, a body would continue to describe the same curve as before; but, by the very compression, the curvatures are increased, supposing them to remain similar. This would require an increase of the transverse forces; but this is not to be found: therefore the particle will not describe a similar curve, but one which is less incurvated in all its parts; consequently the progressive velocity of the whole, which is the only thing perceivable by us, will not be so much diminished; that is, the obstructions will not increase so fast as they would otherwise do, or as the squares of the velocities.

This reasoning is equally applicable to all fluids, and is abundantly confirmed by experiments in hydraulics, as we shall see when considering the motion of rivers. We have taken this opportunity of delivering our notions on this subject; because, as we have often said, it is in the avowed discrete constitution of air that we see most distinctly the operation of those natural powers which constitute fluidity in general.

307 M. Bossut's experiments on pipes and canals.

We would beg leave to mention a form of experiment for discovering the law of retardation with considerable accuracy. Experiments have been made on pipes and canals. Mr Bossut, in his *Hydrodynamique*, has given a very beautiful set made on pipes of an inch and two inches diameter, and 200 feet long: but although these experiments are very instructive, they do not give us any rule by which we can extend the result to pipes of greater length and different diameters.

Let a smooth cylinder be set upright in a very large vessel or pond, and be moveable round its axis: let it be turned round by means of a wheel and pulley with an uniform

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uniform motion and determined velocity. It will exert the ſame force on the contiguous water which would be exerted on it by water turning round it with the ſame velocity: and as this water would have its motion gradually retarded by the fixed cylinder, ſo the moving cylinder will gradually communicate motion to the ſurrounding water. We ſhould obſerve the water gradually dragged round by it; and the vortex would extend farther and farther from it as the motion is continued, and the velocities of the parts of the vortex will be leſs and leſs as we recede from the axis. Now, we apprehend, that when a point of the ſurface of the cylinder has moved over 200 feet, the *motion* of the water at different diſtances from it will be ſimilar and proportional to, if not preciſely the ſame with, the *retardations* of water flowing 200 feet at the ſame diſtance from the ſide of a canal: at any rate, the two are ſuſceptible of an accurate compariſon, and the law of retardation may be accurately deduced from obſervations made on the motions of this vortex.

308 Wind is air in motion.

Air in motion is a very familiar object of obſervation; and it is intereſting. In all languages it has got a name; we call it wind: and it is only upon reflection that we conſider air as wind in a quieſcent ſtate. Many perſons hardly know what is meant when air is mentioned; but they cannot refuſe that the blaſt from a bellows is the expulſion of what they contained; and thus they learn that wind is air in motion.

309 The velocity of wind not eaſily diſcovered.

It is of conſequence to know the velocity of wind; but no good and unexceptionable method has been contrived for this purpoſe. The beſt ſeems to be by meaſuring the ſpace paſſed over by the ſhadow of a cloud; but this is extremely fallacious. In the firſt place, it is certain, that although we ſuppoſe that the cloud has the velocity of the air in which it is carried along, this is not an exact meaſure of the current on the ſurface of the earth; we may be almoſt certain that it is greater: for air, like all other fluids, is retarded by the ſides and bottom of the channel in which it moves. But, in the next place, it is very gratuitous to ſuppoſe, that the velocity of the cloud is the velocity of the ſtratum of air between the cloud and the earth; we are almoſt certain that it is not. It is abundantly proved by Dr Hutton of Edinburgh, that clouds are always formed when two parcels of air of different temperatures mix together, each containing a proper quantity of vapour in the ſtate of chemical ſolution. We know that different ſtrata of air will frequently flow in different directions for a long time. In 1781 while a great fleet rendezvouzed in Leith Roads during the Dutch war, there was a briſk eaſterly wind for about five weeks; and, during the laſt fortnight of this period, there was a briſk weſterly current at the height of about three-fourths of a mile. This was diſtinctly indicated by frequent fleecy clouds at a great diſtance above a lower ſtratum of theſe clouds, which were driving all this time from the eaſtward. A gentleman who was at the ſiege of Quebec in 1759, informed us, that one day while there blew a gale from the weſt, ſo hard that the ſhips at anchor in the river were obliged to ſtrike their topmaſts, and it was with the utmoſt difficulty that ſome well manned boats could row againſt it, carrying ſome artillery ſtores to a poſt above the town, ſeveral ſhells were thrown from the town to deſtroy the boats: one of the ſhells burſt in the air near the top of its flight, which was about half a mile high. The ſmoke of this bomb remained in the ſame ſpot for above a quarter of an hour, like a great round ball, and gradually diſſipated by diffuſion, without removing many yards from its place. When, therefore, two ſtrata of air come from different quarters, and one of them flows over the other, it will be only in the contiguous ſurfaces that a precipitation of vapour will be made. This will form a thin fleecy cloud; and it will have a velocity and direction which neither belongs to the upper nor to the lower ſtratum of air which produced it. Should one of theſe ſtrata come from the eaſt and the other from the weſt with equal velocities, the cloud formed between them will have no motion at all; ſhould one come from the eaſt, and the other from the north, the cloud will move from the north-eaſt with a greater velocity than either of the ſtrata. So uncertain then is the information given by the clouds either of the velocity or the direction of the wind. A thick ſmoke from a furnace will give us a much leſs equivocal meaſure; and this, combined with the effects of the wind in impelling bodies, or deflecting a loaded plane from the perpendicular, or other effects of this kind, may give us meaſures of the different currents of wind with a preciſion ſufficient for all practical uſes.

310 The reſult of Smeaton's obſervation on this head.

The celebrated engineer Mr John Smeaton has given, in the 51ſt volume of the Philoſophical Tranſactions, the velocities of wind correſponding to the uſual denominations in our language. Theſe are founded on a great number of obſervations made by himſelf in the courſe of his practice in erecting wind-mills. They are contained in the following table.

Miles per hour.	Feet per ſecond.	Names.
1	1.47	
2	2.93	Light airs.
3	4.40	
4	5.87	Breeze.
5	7.33	
10	14.67	Briſk gale.
15	22.	
20	29.34	Freſh gale.
25	36.67	
30	44.01	Strong gale.
35	51.34	
40	58.68	Hard gale.
45	66.01	
50	73.35	Storm.
60	88.02	
80	117.36	Hurricane, tearing up trees, overturning buildings, &c.
100	146.70	

See alſo ſome valuable experiments by him on this ſubject, Philoſophical Tranſactions 1760 and 1761.

311 Account of Dr Lind's anemometer.

One of the moſt ingenious and convenient methods for meaſuring the velocity of the wind is to employ its preſſure in ſupporting a column of water, in the ſame way as Mr Pitot meaſures the velocity of a current of water. We believe that it was firſt propoſed by Dr James Lind of Windſor, a gentleman eminent for his great knowledge in all the branches of natural ſcience, and for his ingenuity in every matter of experiment or practical application.

His anemometer (as theſe inſtruments are called) conſiſts Fig. 84.

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ſiſts of a glaſs tube of the form ABCD (fig. 84.), open at both ends, and having the branch AB at right angles to the branch CD. This tube contains a few inches of water or any fluid (the lighter the better); it is held with the part CD upright, and AB horizontal and in the direction of the wind; that is, with the mouth A fronting the wind. The wind acts in the way of preſſure on the air in AB, compreſſes it, and cauſes it to preſs on the ſurface of the liquor; forcing it down to F, while it riſes to E in the other leg. The velocity of the wind is concluded from the difference E*f* between the heights of the liquor in the legs. As the wind does not generally blow with uniform velocity, the liquor is apt to dance in the tube, and render the obſervation difficult and uncertain: to remedy this, it is proper to contract very much the communication at C between the two legs. If the tube has half an inch of diameter (and it ſhould not have leſs), a hole of $\frac{1}{30}$ of an inch is large enough; indeed the hole can hardly be too ſmall, nor the tubes too large.

312 It is ingenious and uſeful.

This inſtrument is extremely ingenious, and will undoubtedly give the proportions of the velocities of different currents with the greateſt preciſion; for in whatever way the preſſure of wind is produced by its motion, we are certain that the different preſſures are as the ſquares of the velocities: if, therefore, we can obtain one certain meaſure of the velocity of the wind, and obſerve the degree to which the preſſure produced by it raiſes the liquor, we can at all other times obſerve the preſſures and compute the velocities from them, making proper allowances for the temperature and the height of the mercury in the barometer; becauſe the velocity will be in the ſubduplicate ratio of the denſity of the air inverſely when the preſſure is the ſame.

It is uſually concluded, that the velocity of the wind is that which would be acquired by falling from a height which is to E*f* as the weight of water is to that of an equal bulk of air. Thus, ſuppoſing air to be 840 times lighter than water, and that E*f* is $\frac{9}{10}$ of an inch, the velocity will be about 63 feet per ſecond, which is that of a very hard gale, approaching to a ſtorm. Hence we ſee by the bye, that the ſcale of this inſtrument is extremely ſhort, and that it would be a great improvement of it to make the leg CD not perpendicular, but very much ſloping; or perhaps the following form of the inſtrument will give it all the perfection of which it is capable.

Fig. 85.

Let the horizontal branch AB (fig. 85.) be contracted at B, and continued horizontally for ſeveral inches BG of a much ſmaller bore, and then turned down for two or three inches GC, and then upwards with a wide bore. To uſe the inſtrument, hold it with the part DC perpendicular; and (having ſheltered the mouth A from the wind) pour in water at D till it advances along GB to the point B, which is made the beginning of the ſcale; the water in the upright branch ſtanding at *f* in the ſame horizontal line with BG. Now, turn the mouth A to the wind; the air in AB will be compreſſed and will force the water along BG to F, and cauſe it to riſe from *f* to E; and the range *f*E will be to the range BF on the ſcale as the ſection of the tube BG to that of CD. Thus, if the width of DC be $\frac{1}{2}$ an inch, and that of BG $\frac{1}{10}$. we ſhall have 25 inches in the ſcale for one inch of real preſſure E*f*.

But it has not been demonſtrated in a very ſatisfactory manner, that the velocity of the wind is that acquired by falling through the height of a column of air whoſe weight is equal to that of the column of water E*f*. Experiments made with Pitot's tube in currents of water ſhow that ſeveral corrections are neceſſary for concluding the velocity of the current from the elevations in the tube: theſe corrections may however be made, and ſafely applied to the preſent caſe; and then the inſtrument will enable us to conclude the velocity of the wind immediately, without any fundamental compariſon of the elevation, with a velocity actually determined upon other principles. The chief uſe which we have for this information is in our employment of wind as an impelling power, by which we can actuate machinery or navigate ſhips. Theſe are very important applications of pneumatical doctrines, and merit a particular conſideration; and this naturally brings us to the laſt part of our ſubject, viz. the conſideration of the impulſe of air on bodies expoſed to its action, and the reſiſtance which it oppoſes to the paſſage of bodies through it.

313 This ſubject is moſt important, but it is alſo difficult.

This is a ſubject of the greateſt importance; being the foundation of that art which has done the greateſt honour to the ingenuity of man, and the greateſt ſervice to human ſociety, by connecting together the moſt diſtant inhabitants of this globe, and making a communication of benefits which would otherwiſe have been impoſſible; we mean the art of Navigation or Seamanſhip. Of all the machines which human art has conſtructed, a ſhip is not only the greateſt and moſt magnificent, but alſo the moſt ingenious and intricate; and the clever ſeaman poſſeſſes a knowledge founded on the moſt difficult and abſtruſe doctrines of mechanics. The ſeaman probably cannot give any account of his own ſcience; and he poſſeſſes it rather by a kind of intuition than by any proceſs of reaſoning; but the ſucceſs and efficacy of all the mechaniſm of this complicated engine, and the propriety of all the manœuvres which the ſeaman practiſes, depend on the invariable laws of mechanics; and a thorough knowledge of theſe would enable an intelligent perſon not only to underſtand the machine and the manner of working it, but to improve both.

Unfortunately this is a ſubject of very great difficulty; and although it has employed the genius of Newton, and he has conſidered it with great care, and his followers have added more to his labours on this ſubject than on any other, it ſtill remains in a very imperfect ſtate.

A minute diſcuſſion of this ſubject cannot therefore be expected in a work like this: we muſt content ourſelves with ſuch a general ſtatement of the moſt approved doctrine on the ſubject as ſhall enable our readers to conceive it diſtinctly, and judge with intelligence and confidence of the practical deductions which may be made from it.

314 Impulſe and reſiſtance of air.

It is evidently a branch of the general theory of the impulſe and reſiſtance of fluids, which belongs to HYDRAULICS, but will be better underſtood when the mechanical properties of compreſſible fluids have been conſidered. It was thought very reaſonable to ſuppoſe that the circumſtances of elaſticity would introduce the ſame changes in the impulſe and reſiſtance of fluids that it does in ſolid bodies. It would greatly divert the attention from the diſtinctive properties of air, if we ſhould in this place enter on this ſubject, which is both extenſive and difficult. We reckon it better therefore to take the whole together: this we ſhall do under the article

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RESISTANCE of Fluids, and confine ourselves at present to what relates to the impulse and resistance of air alone; anticipating a few of the general propositions of that theory, but without demonstration, in order to understand the applications which may be made of it.

Fig. 86.

Suppose then a plane surface, of which *a* C (fig. 86.) is the section, exposed to the action of a stream of wind blowing in the direction QC, perpendicular to *a* C. The motion of the wind will be obstructed, and the surface *a* C pressed forward. And as all impulse or pressure is exerted in a direction perpendicular to the surface, and is resisted in the opposite direction, the surface will be impelled in the direction CD, the continuation of QC. And as the mutual actions of bodies depend on their relative motions, the force acting on the surface *a* C will be the same, if we shall suppose the air at rest, and the surface moving equally swift in the opposite direction. The resistance of the air to the motion of the body will be equal to the impulse of the air in the former case. Thus resistance and impulse are equal and contrary.

315 Air moving with a double velocity will generally impel as the square of that velocity.

If the air be moving twice as fast, its particles will give a double impulse; but in this case a double number of particles will exert their impulse in the same time: the impulse will therefore be fourfold; and in general it will be as the square of the velocity: or if the air and body be both in motion, the impulse and resistance will be proportional to the square of the relative velocity.

This is the first proposition on the subject, and it appears very consonant to reason. There will therefore be some analogy between the force of the air's impulse or the resistance of a body, and the weight of a column of air incumbent on the surface; for it is a principle in the action of fluids, that the heights of the columns of fluid are as the squares of the velocities which their pressures produce. Accordingly the second proposition is, that the absolute impulse of a stream of air, blowing perpendicularly on any surface, is equal to the weight of a column of air which has that surface for its base, and for its height the space through which a body must fall in order to acquire the velocity of the air.

Thirdly, Suppose the surface AC equal to *a* C no longer to be perpendicular to the stream of air, but inclined to it in the angle ACD, which we shall call the *angle of incidence;* then, by the resolution of forces, it follows, that the action of each particle is diminished in the proportion of radius to the sine of the angle of incidence, or of AC to AL, AL being perpendicular to CD.

Again: Draw AK parallel to CD. It is plain that no air lying farther from CD than KA is will strike the plane. The quantity of impulse therefore is diminished still farther in the proportion of *a* C to KC, or of AC to AL. Therefore, on the whole, the absolute impulse is diminished in the proportion of AC^2 to AL^2: hence the proposition, that the impulse and resistance of a given surface are in the proportion of the square of the sine of the angle of incidence.

Fourthly, This impulse is in the direction PL, perpendicular to the impelled surface, and the surface tends to move in this direction: but suppose it moveable only in some other direction PO, or that it is in the direction PO that we wish to employ this impulse, its action is therefore oblique; and if we wish to know the intensity of the impulse in this direction, it must be diminished still farther in the proportion of radius to the cosine of the angle LPO or sine of CPO. Hence the general proposition: The *effective impulse is as the surface, as the square of the velocity of the wind, as the square of the sine of the angle of incidence, and as the sine of the obliquity jointly*, which we may express by the symbol $R = S \cdot V^2 \cdot \mathit{sin.}^2\, I \cdot \mathit{sin.}\, O$; and as the impulse depends on the density of the impelling fluid, we may take in every circumstance by the equation $R = S \cdot D \cdot V^2 \cdot \mathit{sin.}^2\, I \cdot \mathit{sin.}\, O$. If the impulse be estimated in the direction of the stream, the angle of obliquity ACD is the same with the angle of incidence, and the impulse in this direction is as the surface, as the square of the velocity, and as the cube of the angle of incidence jointly.

It evidently follows from these premises, that if ACA′ be a wedge, of which the base AA′ is perpendicular to the wind, and the angle ACA′ bisected by its direction, the direct or perpendicular impulse on the base is to the oblique impulse on the sides as radius to the square of the sine of half the angle ACA′.

The same must be affirmed of a pyramid or cone ACA′, of which the axis is in the direction of the wind.

If ACA′ (fig. 87.) represent the section of a solid, produced by the revolution of a curve line APC round the axis CD, which lies in the direction of the wind, the impulse on this body may be compared with the direct impulse on this base, or the resistance to the motion of this body through the air may be compared with the direct resistance of its base, by resolving its surface into elementary planes P*p*, which are coincident with a tangent plane PR, and comparing the impulse on P*p* with the direct impulse on the corresponding part K*k* of the base. Fig. 87.

In this way it follows that the impulse on a sphere is one half of the impulse on its great circle, or on the base of a cylinder of equal diameter.

We shall conclude this sketch of the doctrine with a very important proposition to determine the most advantageous position of a plane surface, when required to move in one direction while it is impelled by the wind blowing in a different direction. Thus,

316 Important inference from this doctrine.

Let AB (fig. 88.) be the sail of a ship, CA the direction in which the wind blows, and AD the line of the ship's course. It is required to place the yard AC in such a position that the impulse of the wind upon the sail may have the greatest effect possible in impelling the ship along AD.

Let AB, A*b*, be two positions of the sail very near the best position, but on opposite sides of it. Draw BE, *b e*, perpendicular to CA, and BF, *b f*, perpendicular to AD, calling AB radius; it is evident that BE, BF, are the sines of impulse and obliquity, and that the effective impulse is $BE^2 \times BF$, or $be^2 \times bf$. This must be a maximum. Fig. 88.

Let the points B, *b*, continually approach and ultimately coincide; the chord *b* B will ultimately coincide with a straight line CBD touching the circle in B; the triangles CBE, *c b e* are similar, as also the triangles DBF, D*b f*: therefore $BE^2 : be^2 = BC^2 : bc^2$, and $BF : bf = BD : bD$; and $BE^2 \times BF : be^2 \times bf = CB^2 \times BD : cb^2 \times bD$. Therefore when AB is in the best position, so that $BE^2 \times BF$ is greater than $be^2 \times bf$, we shall have $CB \times BD$ greater than $Cb^2 \times bD$, or $cB^2 \times BD$ is

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is alſo a maximum. This we know to be the caſe when CB=2BD: therefore the ſail muſt be ſo placed that the tangent of the angle of incidence ſhall be double of the tangent of the angle of the ſail and keel.

In a common windmill the angle CAD is neceſſarily a right angle; for the ſail moves in a circle to which the wind is perpendicular: therefore the beſt angle of the ſail and axle will be 54°.44 nearly.

Such is the theory of the reſiſtance and impulſe of the air. It is extremely ſimple and of eaſy application. In all phyſical theories there are aſſumptions which depend on other principles, and thoſe on the judgement of the naturaliſt; ſo that it is always proper to confront the theory with experiment. There are even circumſtances in the preſent caſe which have not been attended to in the theory. When a ſtream of air is obſtructed by a ſolid body, or when a ſolid body moves along in air, the air is condenſed before it and rarefied behind. There is therefore a preſſure on the anterior parts ariſing from this want of equilibrium in the elaſticity of the air. This muſt be ſuperadded to the force ariſing from the impetus or inertia of the air. We cannot tell with preciſion what may be the amount of this condenſation; it depends on the velocity with which any condenſation diffuſes itſelf.

Alſo, if the motion be ſo rapid that the preſſure of the atmoſphere cannot make the air immediately occupy the place quitted by the body, it will ſuſtain this preſſure on its fore part to be added to the other forces.

317
Account of the principal experiments on this ſubject.

Experiments on this ſubject are by no means numerous; at leaſt ſuch experiments as can be depended on for the foundation of any practical application. The firſt that have this character are thoſe publiſhed by Mr Robins in 1742 in his treatiſe on Gunnery. They were repeated with ſome additions by the Chevalier Borda, and ſome account of them publiſhed in the Memoirs of the Academy of Sciences in 1763. In the Philoſophical Tranſactions of the Royal Society of London, vol. lxxiii. there are ſome experiments of the ſame kind on a larger ſcale by Mr Edgeworth. Theſe were all made in the way deſcribed in our account of Mr Robins's improvements in gunnery. Bodies were made to move with determined velocities, and the reſiſtances were meaſured by weights.

In all theſe experiments the reſiſtances were found very exactly in the proportion of the ſquares of the velocities; but they were found conſiderably greater than the weight of the column of air, whoſe height would produce the velocity in a falling body. Mr Robins's experiments on a ſquare of 16 inches, deſcribing 25.2 feet per ſecond, indicate the reſiſtance to be to this weight nearly as 4 to 3. Borda's experiments on the ſame ſurface ſtate the diſproportion ſtill greater.

The reſiſtances are found not to be in the proportion of the ſurfaces, but increaſe conſiderably faſter. Surfaces of 9, 16, 36, and 81 inches, moving with one velocity, had reſiſtances in the proportion of 9, $17\frac{1}{2}$, $42\frac{1}{4}$, and $104\frac{1}{4}$.

Now as this deviation from the proportion of the ſurfaces increaſes with great regularity, it is moſt probable that it continues to increaſe in ſurfaces of ſtill greater extent; and theſe are the moſt generally to be met with in practice in the action of wind on ſhips and mills.

Borda's experiments on 81 inches ſhow that the impulſe of wind moving one foot per ſecond is about $\frac{1}{500}$ of a pound on a ſquare foot. Therefore to find the impulſe on a foot correſponding to any velocity, divide the ſquare of the velocity by 500, and we obtain the impulſe in pounds. Mr Rouſe of Leiceſterſhire made many experiments, which are mentioned with great approbation by Mr Smeaton. His great ſagacity and experience in the erection of windmills oblige us to pay a conſiderable deference to his judgement. Theſe experiments confirm our opinion, that the impulſes increaſe faſter than the ſurfaces. The following table was calculated from Mr Rouſe's obſervations, and may be conſidered as pretty near the truth.

Velocity in Feet.	Impulſe on a Foot in Pounds.
0	0,000
10	0,229
20	0,915
30	2,059
40	3,660
50	5,718
60	8,234
70	11,207
80	14,638
90	18,526
100	22,872
110	27,675
120	32,926
130	38,654
140	44,830
150	51,462

If we multiply the ſquare of the velocity in feet by 16, the product will be the impulſe or reſiſtance on a ſquare foot in grains, according to Mr Rouſe's numbers.

The greateſt deviation from the theory occurs in the oblique impulſes. Mr Robins compared the reſiſtance of a wedge, whoſe angle was 90°, with the reſiſtance of its baſe; and inſtead of finding it leſs in the proportion of $\sqrt{2}$ to 1, as determined by the theory, he found it greater in the proportion of 55 to 68 nearly; and when he formed the body into a pyramid, of which the ſides had the ſame ſurface and the ſame inclination as the ſides of the wedge, the reſiſtance of the baſe and face were now as 55 to 39 nearly: ſo that here the ſame ſurface with the ſame inclination had its reſiſtance reduced from 68 to 39 by being put into this form. Similar deviations occur in the experiments of the Chevalier Borda; and it may be collected from both, that the reſiſtances diminiſh more nearly in the proportion of the ſines of incidence than in the proportion of the ſquares of thoſe ſines.

The irregularity in the reſiſtance of curved ſurfaces is as great as in plane ſurfaces. In general, the theory gives the oblique impulſes on plane ſurfaces much too ſmall, and the impulſes on curved ſurfaces too great. The reſiſtance of a ſphere does not exceed the fourth part of the reſiſtance of its great circle, inſtead of being its half; but the anomaly is ſuch as to leave hardly any room for calculation. It would be very deſirable to have the experiments on this ſubject repeated in a greater variety of caſes, and on larger ſurfaces, ſo that the errors of the experiments may be of leſs conſequence.

Till

Till this matter be reduced to some rule, the art of working ships must remain very imperfect, as must also the construction of windmills.

318 It is of great consequence to know the resistance of air in the motion of bullets, &c.

The case in which we are most interested in the knowledge of the resistance of the air is the motion of bullets and shells. Writers on artillery have long been sensible of the great effect of the air's resistance. It seems to have been this consideration that chiefly engaged Sir Isaac Newton to consider the motions of bodies in a resisting medium. A proposition or two would have sufficed for showing the incompatibility of the planetary motions with the supposition that the celestial spaces were filled with a fluid matter; but he has with great solicitude considered the motion of a body projected on the surface of the earth, and its deviation from the parabolic track assigned by Galileo. He has bestowed more pains on this problem than any other in his whole work; and his investigation has pointed out almost all the improvements which have been made in the application of mathematical knowledge to the study of nature. Nowhere does his sagacity and fertility of resource appear in so strong a light as in the second book of the *Principia*, which is almost wholly occupied by this problem. The celebrated mathematician John Bernouilli engaged in it as the finest opportunity of displaying his superiority. A mistake committed by Newton in his attempt to a solution was matter of triumph to him; and the whole of his performance, though a piece of elegant and elaborate geometry, is greatly hurt by his continually bringing this mistake (which is a mere trifle) into view. The difficulty of the subject is so great, that subsequent mathematicians seem to have kept aloof from it; and it has been entirely overlooked by the many voluminous writers who have treated professedly on military projectiles. They have spoken indeed of the resistance of the air as affecting the flight of shot, but have saved themselves from the task of investigating this effect (a task to which they were unequal), by supposing that it was not so great as to render their theories and practical deductions very erroneous. Mr Robins was the first who seriously examined the subject. He showed, that even the Newtonian theory (which had been corrected, but not in the smallest degree improved or extended in its principles) was sufficient to show that the path of a cannon ball could not resemble a parabola. Even this theory showed that the resistance was more than eight times the weight of the ball, and should produce a greater deviation from the parabola than the parabola deviated from a straight line.

319 The ignorance of the writers on artillery in this respect.

This simple but singular observation was a strong proof how faulty the professed writers on artillery had been, in rather amusing themselves with elegant but useless applications of easy geometry, than in endeavouring to give their readers any useful information. He added, that the difference between the ranges by the Newtonian theory and by experiment was so great, that the resistance of the air must be vastly superior to what that theory supposed. It was this which suggested to him the necessity of experiments to ascertain this point. We have seen the result of these experiments in moderate velocities; and that they were sufficient for calling the whole theory in question, or at least for rendering it useless. It became necessary therefore to settle every point by means of a direct experiment. Here was a great difficulty. How shall we measure either these great velocities which are observed in the motions of cannon-shot, or the resistances which these enormous velocities occasion? Mr Robins had the ingenuity to do both. The method which he took for measuring the velocity of a musket-ball was quite original; and it was susceptible of great accuracy. We have already given an account of it under the article GUNNERY. Having gained this point, the other was not difficult. In the moderate velocities he had determined the resistances by the forces which balanced them, the weights which kept the resisted body in a state of uniform motion. In the great velocities, he proposed to determine the resistances by their immediate effects, by the retardations which they occasioned. This was to be done by first ascertaining the velocity of the ball, and then measuring its velocity after it had passed through a certain quantity of air. The difference of these velocities is the retardation, and the proper measure of the resistance; for, by the initial and final velocities of the ball, we learn the time which was employed in passing through this air with the medium velocity. In this time the air's resistance diminished the velocity by a certain quantity. Compare this with the velocity which a body projected directly upwards would lose in the same time by the resistance of gravity. The two forces must be in the proportion of their effects. Thus we learn the proportion of the resistance of the air to the weight of the ball. It is indeed true, that the time of passing through this space is not accurately had by taking the arithmetical medium of the initial and final velocities, nor does the resistance deduced from this calculation accurately correspond to this mean velocity; but both may be accurately found by the experiment by a very troublesome computation, as is shown in the 5th and 6th propositions of the second book of Newton's *Principia*. The difference between the quantities thus found and those deduced from the simple process is quite trifling, and far within the limits of accuracy attainable in experiments of this kind; it may therefore be safely neglected.

Mr Robins made many experiments on this subject; but unfortunately he has published only a very few, such as were sufficient for ascertaining the point he had in view. He intended a regular work on the subject, in which the gradual variations of resistance corresponding to different velocities should all be determined by experiment: but he was then newly engaged in an important and laborious employment, as chief engineer to the East India Company, in whose service he went out to India, where he died in less than two years. It is to be regretted that no person has prosecuted these experiments. It would be neither laborious nor difficult, and would add more to the improvement of artillery than any thing that has been done since Mr Robins's death, if we except the prosecution of his experiments on the initial velocities of cannon-shot by Dr Charles Hutton royal professor at the Woolwich Academy. It is to be hoped that this gentleman, after having with such effect and success extended Mr Robins's experiments on the initial velocities of musket-shot to cannon, will take up this other subject, and thus give the art of artillery all the scientific foundation which it can receive in the present state of our mathematical knowledge. Till then we must content ourselves with the practical rules which Robins has deduced from his own experiments. As he has not given us the mode of deduction, we must compare the results with 320

Mr Robins made many experiments on this subject.

with experiment. He has indeed given a very extenſive compariſon with the numerous experiments made both in Britain and on the continent; and the agreement is very great. His learned commentator Euler has been at no pains to inveſtigate theſe rules, and has employed himſelf chiefly in detecting errors, moſt of which are ſuppoſed, becauſe he takes for a finiſhed work what Mr Robins only gives to the public as a haſty but uſeful ſketch of a new and very difficult branch of ſcience.

321 General reſult of them, &c.

The general reſult of Robins's experiments on the retardation of muſket-ſhot is, that although in moderate velocities the reſiſtance is ſo nearly in the duplicate proportion of the velocities that we cannot obſerve any deviation, yet in velocities exceeding 200 feet per ſecond the retardations increaſe faſter, and the deviation from this rate increaſes rapidly with the velocity. He aſcribes this to the cauſes already mentioned, viz. the condenſation of the air before the ball and to the rarefaction behind, in conſequence of the air not immediately occupying the ſpace left by the bullet. This increaſe is ſo great, that if the reſiſtance to a ball moving with the velocity of 1700 feet in a ſecond be computed on the ſuppoſition that the reſiſtance obſerved in moderate velocities is increaſed in the duplicate ratio of the velocity, it will be found hardly one-third part of its real quantity. He found, for inſtance, that a ball moving through 1670 feet in a ſecond loſt about 125 feet per ſecond of its velocity in paſſing through 50 feet of air. This it muſt have done in the $\frac{1}{32}$ of a ſecond, in which time it would have loſt one foot if projected directly upwards; from which it appears that the reſiſtance was about 125 times its weight, and more than three times greater than if it had increaſed from the reſiſtance in ſmall velocities in the duplicate ratio of the velocities. He relates other experiments which ſhow ſimilar reſults.

But he alſo mentions a ſingular circumſtance, that till the velocities exceed 1100 feet per ſecond, the reſiſtances increaſe pretty regularly, in a ratio exceeding the duplicate ratio of the velocities; but that in greater velocities the reſiſtances become ſuddenly triple of what they would have been, even according to this law of increaſe. He thinks this explicable by the vacuum which is then left behind the ball, it being well known that air ruſhes into a vacuum with the velocity of 1132 feet

322 Partly controverted by Euler, but without ſufficient grounds.

per ſecond nearly. Mr Euler controverts this concluſion, as inconſiſtent with that gradation which is obſerved in all the operations of nature; and ſays, that although the vacuum is not produced in ſmaller velocities than this, the air behind the ball muſt be ſo rare (the ſpace being but imperfectly filled), that the preſſure on the anterior part of the ball muſt gradually approximate to that preſſure which an abſolute vacuum would produce; but this is like his other criticiſms. Robins does nowhere aſſert that this ſudden change of reſiſtance happens in the tranſition of the velocity from 1132 feet to that of 1131 feet 11 inches or the like, but only that it is very ſudden and very great. It may be ſtrictly demonſtrated, that ſuch a change muſt happen in a narrow enough limit of velocities to juſtify the appellation of ſudden: a ſimilar fact may be obſerved in the motion of a ſolid through water. If it be gradually accelerated, the water will be found nearly to fill up its place, till the velocity arrives at a certain magnitude, correſponding to the immerſion of the body in the water; and then the ſmalleſt augmentation of its motion immediately produces a void behind it, into which the water ruſhes in a violent manner and is daſhed into froth. A gentleman, who has had many opportunities for ſuch obſervations, aſſures us, that when ſtanding near the line of direction of a cannon diſcharging a ball with a large allotment of powder, ſo that the initial velocity certainly exceeded 1100 feet per ſecond, he always obſerved a very ſudden diminution of the noiſe which the bullet made during its paſſage. Although the ball was coming towards him, and therefore its noiſe, if equable, would be continually increaſing, he obſerved that it was loudeſt at firſt. That this continued for a ſecond or two, and ſuddenly diminiſhed, changing to a ſound which was not only weaker, but differed in kind, and gradually increaſed as the bullet approached him. He ſaid, that the firſt noiſe was like the hiſſing of red-hot iron in water, and that the ſubſequent noiſe rather reſembled a hazy whiſtling. Such a change of ſound is a neceſſary conſequence of the different agitation of the air in the two caſes. We know alſo, that air ruſhing into a void, as when we break an exhauſted bottle, makes a report like a muſket.

Mr Robins's aſſertion therefore has every argument for its truth that the nature of the thing will admit. But we are not left to this vague reaſoning: his experiments ſhow us this diminution of reſiſtance. It clearly appears from them, that in a velocity of 1700 feet the reſiſtance is more than three times the reſiſtance determined by the theory which he ſuppoſes the common one. When the velocity was 1065 feet, the actual reſiſtance was $\frac{11}{7}$ of the theoretical; and when the velocity was 400 feet, the actual reſiſtance was about $\frac{4}{3}$ of the theoretical. That he aſſumed a theory of reſiſtance which gave them all too ſmall, is of no conſequence in the preſent argument.

323 Rule by Robins for computing reſiſtances and very rapid motions.

Mr Robins, in ſumming up the reſults of his obſervations on this ſubject, gives a rule very eaſily remembered for computing the reſiſtances to thoſe very rapid motions. It has been already mentioned in the article Gunnery, but we repeat it here, in order to accommodate it to the quantities which have been determined in ſome degree by experiment.

Let AB repreſent the velocity of 1700 feet per ſecond, and AC any other velocity. Make BD to AD as the reſiſtance given by the ordinary theory to the reſiſtance actually obſerved in the velocity 1700: then will CD be to AD as the reſiſtance aſſigned by the ordinary theory to the velocity AC is to that which really correſponds to it.

To accommodate this to experiment, recollect * that a ſphere of the ſize of a 12 pound iron ſhot, moving 25 feet in a ſecond, had a reſiſtance of $\frac{1}{22}$ of a pound. Augment this in the ratio of 25^2 to 1700^2, and we obtain 210 nearly for the theoretical reſiſtance to this velocity; but by comparing its diameter of $4\frac{1}{2}$ inches with $\frac{3}{4}$, the diameter of the leaden ball, which had a reſiſtance of at leaſt 11 pounds with this velocity, we conclude that the 12 pound ſhot would have had a reſiſtance of 396 pounds: therefore BD; AD=210 : 396, and AB : AD=186 : 396; and AB being 1700, AD will be 3613.

* See *Gunnery*, n° 19, &c.

Let AD=a, AC=x, and let R be the reſiſtance to a 12 pound iron ſhot moving one foot per ſecond, and r the reſiſtance (in pounds) wanted for the velocity x;

we

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we have $r = R\frac{a x^2}{a-x}$. Mr Robins's experiments give $R = \frac{1}{13750}$ very nearly. This gives $Ra = 0{,}263235$, which is nearly one fourth. Thus our formula becomes $r = \frac{0.263235\, x^2}{3613-x}$, or very nearly $\frac{x^2}{4(3613-x)}$, falling short of the truth about $\frac{1}{50}$th part. The simplicity of the formula recommends it to our use, and when we increase its result $\frac{1}{50}$, it is incomparably nearer to the true result of the theory as corrected by Mr Robins than we can hope that the theory is to the actual resistance. We can easily see that Mr Robins's correction is only a sagacious approximation. If we suppose the velocity 3613 feet, a very possible thing, the resistance by this formula is infinite, which cannot be. We may even suppose that the resistance given by the formula is near the truth only in such velocities as do not greatly exceed 1700 feet per second. No military projectile exceeds 2200, and it is great folly to make it so great, because it is reduced to 1700 almost in an instant, by the enormous resistance.

The resistance to other balls will be made by taking them in the duplicate ratio of the diameters.

324 The discussions of mathematicians not easily applied.

It has been already observed, that the first mathematicians of Europe have lately employed themselves in improving this theory of the motion of bodies in a resisting medium; but their discussions are such as few artillerists can understand. The problem can only be solved by approximation, and this by the quadrature of very complicated curves. They have not been able therefore to deduce from them any practical rules of easy application, and have been obliged to compute tables suited to different cases. Of these performances, that of the Chevalier Borda, in the Memoirs of the Academy of Sciences for 1769, seems the best adapted to military readers, and the tables are undoubtedly of considerable use; but it is not too much to say, that the simple rules of Mr Robins are of as much service, and are more easily remembered: besides, it must be observed, that the nature of military service does not give room for the application of any very precise rule. The only advantage that we can derive from a perfect theory would be an improvement in the construction of pieces of ordnance, and a more judicious appropriation of certain velocities to certain purposes. The service of a gun or mortar must always be regulated by the eye.

325 Borda's and Robins's apparently the best.

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There is another motion of which air and other elastic fluids are susceptible, viz. an internal vibration of their particles, or undulation, by which any extended portion of air is distributed into alternate parcels of condensed and rarefied air, which are continually changing their condition without changing their places. By this change the condensation which is produced in one part of the air is gradually transferred along the mass of air to the greatest distances in all directions. It is of importance to have some distinct conception of this motion. It is found to be by this means that distant bodies produce in us the sensation of sound. See ACOUSTICS. Sir Isaac Newton treated this subject with his accustomed ingenuity, and has given us a theory of it in the end of the second book of his *Principia*. This theory has been objected to with respect to the conduct of the argument, and other explanations have been given by the most eminent mathematicians. Though they appear to differ from Newton's, their results are precisely the same; but, on a close examination, they differ no more than John Bernoulli's theorem of centripetal forces differs from Newton's, viz. the one being expressed by geometry and the other by literal analysis. The celebrated De la Grange reduces Newton's investigation to a tautological proposition or identical equation; but Mr Young of Trinity college, Dublin, has, by a different turn of expression, freed Newton's method from this objection. We shall not repeat it here, but refer our mathematical readers to the article ACOUSTICS, as it is not our business at present to consider its connection with sound.

327 Has been used to explain a variety of natural phenomena.

But since Newton published this theory of aerial undulations, and of their propagation along the air, and since the theory has been so corrected and improved as to be received by the most accurate philosophers as a branch of natural philosophy susceptible of rigid demonstration, it has been freely resorted to by many writers on other parts of natural science, who did not profess to be mathematicians, but made use of it for explaining phenomena in their own line on the authority of the mathematicians themselves. Learning from them that this vibration, and the *quaquaversum* propagation of the pulses, were the necessary properties of an elastic fluid, and that the rapidity of this propagation had a certain assignable proportion to the elasticity and density of the fluid, they freely made use of these concessions, and have introduced elastic vibrating fluids into many facts, where others would suspect no such thing, and have attempted to explain by their means many abstruse phenomena of nature. Æthers are everywhere introduced, endued with great elasticity and tenuity. Vibrations and pulses are supposed in this æther, and these are offered as explanations. The doctrines of animal spirits and nervous fluids, and the whole mechanical system of Hartley, by which the operations of the soul are said to be explained, have their foundation in this theory of aerial undulations. If these fancied fluids, and their internal vibrations, really operate in the phenomena ascribed to them, any explanation that can be given of the phenomena from this principle must be nothing else than showing that the legitimate consequences of these undulations are similar to the phenomena; or, if we are no more able to see this last step than in the case of sound (which we know to be *one* consequence of the aerial undulations, although we cannot tell how), we must be able to point out, as in the case of sound, certain constant relations between the general laws of these undulations and the general laws of the phenomena. It is only in this way that we think ourselves intitled to say that the aerial undulations are causes, though not the only causes, of sound; and it is because there is no such relation, but, on the contrary, a total dissimilarity, to be observed between the laws of elastic undulations and the laws of the propagation of light, that we assert with confidence that ethereal undulations are not the causes of vision.

328 But the application not being made with sufficient precision,

Explanations of this kind suppose, therefore, in the first place, that the philosopher who proposes them understands precisely the nature of these undulations; in the next place, that he makes his reader sensible of those circumstances of them which are concerned in the effect to be explained; and, in the third place, that he makes the reader understand how this circumstance of the vibrating fluid is connected with the phenomenon, either by showing it to be its mechanical cause, as as when the philosopher explains the resounding of a musical chord to a flute or pipe which gave the same tone; or by showing that this circumstance of the undulation always accompanies the phenomenon, as when the philosopher shows that 233 vibrations of air in a second, in whatever manner or by whatever cause they are produced always are followed by the sensation of the tone C in the middle of the harpsichord.

But here we must observe, that, with the exception of Euler's unsuccessful attempt to explain the optical phenomena by the undulations of ether, we have met with no explanation of natural phenomena, by means of elastic and vibrating fluids, where the author has so much as attempted any one of these three things, so indispensably requisite in a logical explanation. They have talked of vibrations without describing them, or giving the reader the least notion of what kind they are; and in no instance that we can recollect have they showed how such vibrations could have any influence in the phenomenon. Indeed, by not describing with precision the undulations, they were freed from the task of showing them to be mechanical causes of the phenomenon; and when any of them show any analogy between the general laws of elastic undulations and the general laws of the phenomenon, the analogy is so vague, indistinct, or partial, that no person of common prudence would receive it as argument in any case in which he was much interested.

329 has become the foundation of materialism.

We think it our duty to remonstrate against this slovenly way of writing: we would even hold it up to reprobation. It has been chiefly on this faithless foundation that the blind vanity of men has raised that degrading system of opinions called MATERIALISM, by which the affections and faculties of the soul of man have been resolved into vibrations and pulses of ether.

330 Of the motion of elastic fluids.

We also think it our duty to give some account of this motion of elastic fluids. It must be such an account as shall be understood by those who are not mathematicians, because those only are in danger of being misled by the improper application of them. Mathematical discussion is, however, unavoidable in a subject purely mathematical; but we shall introduce nothing that may not be easily understood or confided in; and we trust that mathematical readers will excuse us for a mode of reasoning which appears to them lax and inelegant.

331 How they differ from unelastic fluids in propagating any agitation of their parts.

The first thing incumbent on us is to show how elastic fluids differ from the unelastic in the propagation of any agitation of their parts. When a long tube is filled with water, and any one part of it pushed out of its place, the whole is instantly moved like a solid mass. But this is not the case with air. If a door be suddenly shut, the window at the farther end of a long and close room will rattle; but some time will elapse between the shutting of the door and the motion of the window. If some light dust be lying on a braced drum, and another be violently beat at a little distance from it, an attentive observer will see the dust dance up from the parchment; but this will be at the instant he hears the sound of the stroke on the other drum, and a sensible time after the stroke. Many such familiar facts show that the agitation is gradually communicated along the air; and therefore that when one particle is agitated by any sensible motion, a finite time, however small, must elapse before the adjoining particle is agitated in the same manner. This would not be the case in water if water be perfectly incompressible. We think that this may be made intelligible with very little trouble.

Let A, B, C, D, &c, be a row of aerial particles, at such distances that their elasticity just balances the pressure of the atmosphere; and let us suppose (as is deducible from the observed density of air being proportional to the compressing force) that the elasticity of the particles, by which they keep each other at a distance, is as their distances inversely. Let us farther suppose that the particle A has been carried, with an uniform motion, to *a* by some external force. It is evident that B cannot remain in its present state; for being now nearer to *a* than to C, it is propelled towards C by the excess of the elasticity of A above the natural elasticity of C. Let E be the natural elasticity of the particles, or the force corresponding to the distance BC or BA, and let F be the force which impels B towards C, and let f be the force exerted by A when at *a*. We have

$$E : f = Ba : BC, = Ba \quad BA;$$
$$\text{and } E : f - E = Ba : BA - Ba = Ba : Aa;$$
$$\text{or } E : F = Ba : Aa.$$

Now in fig. 89. let ABC be the line joining three particles, to which draw FG, PH parallel, and IAF, HBG perpendicular. Take IF or HG to represent the elasticity corresponding to the distance AB. Let the particle A be supposed to have been carried with an uniform motion to *a* by some external force, and draw R*a*M perpendicular to RG, and make FI : RM = B*a* : BA. We shall then have FI : PM = B*a* : A*a*; and PM will represent the force with which the particle B is urged towards C. Suppose this construction to be made for every point of the line AB, and that a point M is thus determined for each of them, mathematicians know that all these points M lie in the curve of a hyperbola, of which FG and GH are the asymptotes. It is also known by the elements of mechanics, that since the motion of A along AB is uniform, A*a* or IP may be taken to represent the time of describing A*a*; and that the area IPM represents the whole velocity which B has acquired in its motion towards C when A has come to *a*, the force urging B being always as the portion PM of the ordinate. Fig. 89.

Take GX of any length in HG produced, and let GX represent the velocity which the uniform action of the natural elasticity IF could communicate to the particle B during the time that A would uniformly describe AB. Make GX to GY as the rectangle IFGH to the hyperbolic space IFRM, and draw YS cutting MR produced in S, and draw FX cutting MR in T. It is known to the mathematicians that the point S is in a curve line FS*s* called the *logarithmic curve*; of which the leading property is, that any line RS parallel to GX is to GX as the rectangle IFGH is to the hyperbolic space IFRM, and that FX touches the curve in F.

This being the case, it is plain, that because RT increases in the same proportion with FR, or with the rectangle IFRP, and RS increases in the proportion of the space IFRM, TS increases in the proportion of the space IPM. Therefore TS is proportional to the velocity of

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of B when A has reached *a*, and RT is proportional to the velocity which the uniform action of the natural elasticity would communicate to B in the same time. Then since FT is as the time, and TS is as the velocity, the area FTS will be as the space described by B (urged by the variable force PM); while A, urged by the external force, describes A *a*; and the triangle FRT will represent the space which the uniform action of the natural elasticity would cause B to describe in the same time.

And thus it is plain that these three motions can be compared together: the uniform motion of the agitated particle A, the uniformly accelerated motion which the natural elasticity would communicate to B by its constant action, and the motion produced in B by the agitation of A. But this comparison, requiring the quadrature of the hyperbola and logarithmic curve, would lead us into most intricate and tedious computations. Of these we need only give the result, and make some other comparisons which are palpable.

Let A*a* be supposed indefinitely small in comparison of AB. The space described by A is therefore indefinitely small; but in this case we know that the ratio of the space FRT to the rectangle IFRP is indefinitely small. There is therefore no comparison between the agitation of A by the external force, and the agitation which natural elasticity would produce on a single particle in the same time, the last being incomparably smaller than the first. And this space FRT is incomparably greater than FTS; and therefore the space which B would describe by the uniform action of the natural elasticity is incomparably greater than what it would describe in consequence of the agitation of A.

From this reasoning we see evidently that A must be sensibly moved, or a finite or measurable time must elapse before B acquires a measurable motion. In like manner B must move during a measurable time before C acquires a measurable motion, &c.; and therefore the agitation of A is communicated to the distant particles in gradual succession.

By a farther comparison of these spaces we learn the time in which each succeeding particle acquires the very agitation of A. If the particles B and C only are considered, and the motion of C neglected, it will be found that B has acquired the motion of A a little before it has described $\frac{1}{7}$ of the space described by A; but if the motion of C be considered, the acceleration of B must be increased by the retreat of C, and B must describe a greater space in proportion to that described by A. By computation it appears, that when both B and C have acquired the velocity of A, B has described nearly $\frac{1}{6}$ of A's motion, and C more nearly $\frac{1}{7}$. Extending this to D, we shall find that D has described still more nearly $\frac{1}{4}$ of A's motion. And from the nature of the computation it appears that this approximation goes on rapidly: therefore, supposing it accurate from the very first particle, it follows from the equable motion of A, that each succeeding particle moves through an equal space in acquiring the motion of A.

The conclusion which we must draw from all this is, that when the agitation of A has been fully communicated to a particle at a *sensible* distance, the intervening particles, all moving forward with a common velocity, are equally compressed as to sense, except a very few of the first particles; and that this communication, or this propagation of the original agitation, goes on with an uniform velocity.

These computations need not be attended to by such as do not wish for an accurate knowledge of the precise agitation of each particle. It is enough for such readers to see clearly that time *must* escape between the agitation of A and that of a distant particle; and this is abundantly manifest from the incomparability (excuse the term) of the nascent rectangle IFRP with the nascent triangle FRT, and the incomparability of FRT with FTS.

What has now been shown of the communication of any sensible motion A *a* must hold equally with respect to any change of this motion. Therefore if a tremulous motion of a body, such as a spring or bell, should agitate the adjoining particle A by pushing it forward in the direction AB, and then allowing it to come back again in the direction BA, an agitation similar to this will take place in all the particles of the row one after the other. Now if this body vibrate according to the law of motion of a pendulum vibrating in a cycloid, the neighbouring particle of air *will of necessity* vibrate in the same manner; and then Newton's demonstration in art. ACOUSTICS needs no apology. Its only deficiency was, that it *seemed* to prove that this *would be* the way in which every particle would of necessity vibrate; which is not true, for the successive parcels of air will be differently agitated according to the original agitation. Newton only wants to prove the uniform propagation of the agitations, and he selects that form which renders the proof easiest. He proves, in the most unexceptionable manner, that if the particles of a pulse of air are really moving like a cycloidal pendulum, the forces acting on each particle, in consequence of the compression and dilatation of the different parts of the pulse, are precisely such as are necessary for continuing this motion, and therefore no other forces are required. Then since each particle is in a certain part of its path, is moving in a certain direction, and with a certain velocity, and urged by a determined force, it *must* move in that very manner. The objection started by John Bernouilli against Newton's demonstration (in a single line) of the elliptical motion of a body urged by a force in the inverse duplicate ratio of the distance from the focus, is precisely the same with the objection against Newton's demonstration of the progress of aerial undulations, and is equally futile.

332 Newton's demonstration on this subject just as far as it goes;

It must, however, be observed, that Newton's demonstration proceeds on the supposition that the linear agitations of a particle are incomparably smaller than the extent of an undulation. This is not strictly the case in any instance, and in many it is far from being true. In a pretty strong twang of a harpsichord wire, the agitation of a particle may be near the 50th part of the extent of the undulation. This must disturb the regularity of the motion, and cause the agitations in the remote undulations to differ from those in the first pulse. In the explosion of a cannon, the breaking of an exhausted bottle, and many instances which may be given, the agitations are still greater. The commentators on Newton's *Principia*, Le Sueur and Jacquier, have shown, and Euler more clearly, that when the original agitations are very violent, the particles of air will acquire a subordinate vibration compounded with the regular cycloidal vibration, and the progress of the pulses will be somewhat

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somewhat more rapid; but the intricacy of the calculus is so great, that they have not been able to determine with any tolerable precision what the change of velocity will be.

333 It is strengthened by comparing the sound of a cannon near and at a distance.

All this, however, is fully confirmed by experiment on sounds. The sound of a cannon at 10 or 20 miles distance does not in the least resemble its sound when near. In this case it is a loud instantaneous crack, to which we can assign no musical pitch: at a distance, it is a grave sound, of which we can tell the note; and it begins softly, swells to its greatest loudness, and then dies away growling. The same may be said of a clap of thunder, which we know to be a loud snap of still less duration. It is highly probable that the appreciable tones which those distant sounds afford are produced by the continuance of these subordinate vibrations which are added together and fortified in the successive pulses, though not perceptible in the first, in a way somewhat resembling the resonance of a musical chord. Newton's explanation gathers evidence therefore from this circumstance. And we must further observe, that all elastic bodies tremble or vibrate almost precisely as a pendulum swinging in a cycloid, unless their vibrations are uncommonly violent; in which case they are quickly reduced to a moderate quantity by the resistance of the air. The only very loud sounds which we can produce in this way are from great bells; and in these the utmost extent of the vibration is very small in comparison with the breadth of the pulse. The velocity of these sounds has not been compared with that of cannon, or perhaps it would be found less, and an objection against Newton's determination removed. He gives 969 feet per second, Experiment 1142.

334 The agitation in all probability in the successive pulses assumes a cycloidal form.

But it is also very probable, that in the propagation through the air, the agitation gradually and rapidly approaches to this regular cycloidal form in the successive pulses, in the same way as we observe that whatever is the form of agitation in the middle of a smooth pond of water, the spreading circles are always of one gentle form without asperities. In like manner, into whatever form we throw a stretched cord by the twang which we give it, it almost immediately makes smooth undulations, keeping itself in the shape of an elongated trochoid. Of this last we can demonstrate the necessity, because the case is simple. In the wave, the investigation is next to impossible; but we see the fact. We may therefore presume it in air. And accordingly we know that any noise, however abrupt and jarring, near at hand, is smooth at a distance. Nothing is more rough and harsh than the scream of a heron; but at half a mile's distance it is soft. The ruffle of a drum is also smooth at a distance.

Plate CCCCXXXII. fig. 90.

Fig. 90. shows the successive situations of the particles of a row. Each line of the figure shows the same particles marked with the same letters; the first particle *a* being supposed to be removed successively from its quiescent situation and back to it again. The mark × is put on that part of each line where the agitated particles are at their natural distances, and the air is of the natural density. The mark I is put where the air is most of all compressed, and : where it is most of all dilated; the curve line drawn through the lowest line of the figure is intended to represent the density in every point, by drawing ordinates to it from the straight line: the ordinates below the line indicate a rarity, and those above the line a density, greater than common.

It appears that when *a* has come back to its natural situation, the part of greatest density is between the particles *i* and *k*, and the greatest rarity between *c* and *d*.

We have only to add, that the velocity of this propagation depends on the elasticity and density of the fluid. If these vary in the same proportion, that is, if the fluid has its elasticity proportional to its density, the velocity will remain the same. If the elasticity or density alone be changed, the velocity of the undulations will change in the direct subduplicate ratio of the elasticity and the inverse subduplicate ratio of the density; for should the elasticity be quadrupled, the quantity of motion produced by it in any given time will be quadrupled. This will be the case if the velocity be doubled; for there would then be double the number of particles doubly agitated. Should the density be quadrupled, the elasticity remaining the same, the quantity of motion must remain the same. This will be the case if the velocity be reduced to one half; for this will propagate half the agitation to half the distance, which will communicate it to twice the number of particles, and the quantity of motion will remain the same. The same may be said of other proportions, and therefore

$V=\frac{\sqrt{E}}{\sqrt{D}}$. Therefore a change in the barometer will not affect the velocity of the undulations in air; but they will be accelerated by heat, which diminishes its density, or increases its elasticity. The velocity of the pulses in inflammable air must be at least thrice as great, because its density is but one-tenth of that of air when the elasticity of both are the same.

335 Farther considerations of aerial pulses as they really occur.

Let us now attend a little to the propagation of aerial pulses as they really happen; for this hypothesis of a single row of particles is nowhere to be observed.

Fig. 91.

Suppose a sphere A, fig. 91. filled with condensed air, and that the vessel which contains it is suddenly annihilated. The air must expand to its natural dimensions, suppose BCD. But it cannot do this without pressing aside the surrounding air. We have seen that in any single row of particles this cannot be at once diffused to a distance, but must produce a condensation in the air adjoining; which will be gradually propagated to a distance. Therefore this sphere BCD of the common density will form round it a shell, bounded by EFG, of condensed air. Suppose that at this instant the inner air BCD becomes solid. The shell of condensed air can expand only outwards. Let it expand till it is of the common density, occupying the shell HIK. This expansion, in like manner, must produce a shell of condensed air without it: at this instant let HIK become solid. The surrounding shell of condensed air can expand only outward, condensing another shell without it. It is plain that this must go on continually, and the central agitation will be gradually propagated to a distance in all directions. But, in this process, it is not the same numerical particles that go to a distance. Those of the original sphere go no further than BCD, those of the next shall go no further than HIK, &c. Farther, the expansion outwards of any particle will be more moderate as the diffusion advances; for the whole motion of each

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each shell cannot exceed the original quantity of motion; and the number of particles in each successive shell increases as the surface, that is, as the square of the distance from the centre; therefore the agitation of the particles will decrease in the same ratio, or will be in the inverse duplicate ratio of the distance from the centre. Each successive shell, therefore, contains the same quantity of motion, and the successive agitations of the particles of any row out from the centre will not be equal to the original agitation, as happens in the solitary row. But this does not affect the velocity of the propagation, because all agitations are propagated equally fast.

We supposed the air A to become solid as soon as it acquired the common density; but this was to facilitate the conception of the diffusion. It does not stop at this bulk; for while it was denser it had a tendency to expand. Therefore each particle has attained this distance with an accelerated motion. It will, therefore, continue this motion like a pendulum that has passed the perpendicular, till it is brought to rest by the air without it; and it is now rarer than common air, and collapses again by the greater elasticity of the air without it. This outward air, therefore, in regaining its natural density, must expand both ways. It expands towards the centre, following the collapsing of the air within it; and it expands outwards, condensing the air beyond it. By expanding inwards, it will again condense the air within it, and this will again expand; a similar motion happens in all the outward shells; and thus there is propagated a succession of condensed and rarefied shells of air, which gradually swell to the greatest distance.

It may be demonstrated, that when the central air has for the second time acquired the natural density, it will be at rest, and be disturbed no more; and that this will happen to all the shells in succession. But the demonstration is much too intricate for this place; we must be contented with pointing out a fact perfectly analogous. When we drop a small pebble into water, we see it produce a series of circular waves, which go along the surface of smooth water to a great distance, becoming more and more gentle as they recede from the centre; and the middle, where the agitation was first produced, remains perfectly smooth, and this smoothness extends continually; that is, each wave when brought to a level remains at rest. Now these waves are produced and propagated by the depression and elevation made at the centre. The elevation tends to diffuse itself; and the force with which each particle of water is actuated is a force acting directly up and down, and is proportional to the elevation or depression of the particle. This hydrostatical pressure operates precisely in the same way as the condensation and rarefaction of the air; and the mathematical investigation of the propagation of the circular undulations on smooth water is similar in every step to that of the propagation of the spherical waves in still air. For this we appeal to Newton's *Principia*, or to Euler's *Opuscula*, where he gives a very beautiful investigation of the velocity of the aerial pulses; and to some memoirs of de la Grange in the collections of the academies of Berlin and Turin. These two last authors have made the investigation as simple as seems possible, and have freed it from every objection which can be stated against the geometrical one of their greater teacher Newton.

336 Application of the fact of dropping a pebble into water.

Having said this much on the similarity between the waves on water and the aerial undulations, we shall have recourse to them, as affording us a very sensible object to represent many affections of the other which it would be extremely difficult to explain. We neither see nor feel the aerial undulations; and they behoved, therefore, to be described very abstractedly and imperfectly. In the watery wave there is no permanent progressive motion of the water from the centre. Throw a small bit of cork on the surface, and it will be observed to popple up and down without the least motion outwards. In like manner, the particles of air are only agitated a very little outwards and inwards; which motion is communicated to the particles beyond them, while they themselves come to rest, unless agitated afresh; and this agitation of the particles is inconceivably small. Even the explosion of a cannon at no great distance will but gently agitate a feather, giving it a single impulse outwards, and immediately after another inwards or towards the cannon. When a harpsichord wire is forcibly twanged at a few feet distance, the agitation of the air is next to insensible. It is not, however, nothing; and it differs from that in a watery wave by being *really* outwards and inwards. In consequence of this, when the condensed shell reaches an elastic body, it impels it slightly. If its elasticity be such as to make it acquire the opposite shape at the instant that the next agitation and condensed shell of air touches it, its agitation will be doubled, and a third agitation will increase it, and so on, till it acqure the agitation competent to that of the shell of air which reaches it, and it is thrown into *sensible* vibration, and gives a sound extremely faint indeed, because the agitation which it acquires is that corresponding to a shell of air considerably removed from the original string. Hence it happens that a musical chord, pipe, or bell, will cause another to resound, whose vibrations are isochronous with its own; or if the vibrations of the one coincides with every second, or third, or fourth, &c. of the other; just as we can put a very heavy pendulum into sensible motion by giving it a gentle puff with the breath at every vibration, or at every second, third, or fourth, &c. A drum struck in the neighbourhood of another drum will agitate it *very sensibly*; for here the stroke depresses a very considerable surface, and produces an agitation of a considerable mass of air: it will even agitate the surface of stagnant water. The explosion of a cannon will even break a neighbouring window. The shell of condensed air which comes against the glass has a great surface and a great agitation: the best security in this case is to throw up the sash; this admits the condensed air into the room, which acts on the inside of the window, balancing part of the external impulse.

337 The waves of water are useful for explaining those of air.

It is demonstrated in every elementary treatise of natural philosophy, that when a wave on water meets any plane obstacle, it is reflected by it from a centre equally removed behind the obstacle; that waves radiating from the focus of a parabola are reflected in waves perpendicular to its axis; that waves radiating from one focus of an ellipse are made to converge to the other focus, &c. &c. All this may be affirmed of the aerial undulations; that when part of a wave gets through a hole in the obstacle, it becomes the centre of a new series of waves; that waves bend round the extremities of

338 For waves of air and of water are in many respects very similar.

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of an obstacle: all this happens in the aerial undulations. And lastly, that when the surface of water is thrown into regular undulations by one agitation, another agitation in another place will produce other regular waves, which will cross the former without disturbing them in the smallest degree. The same thing happens in air; and experiments may be made on water which will illustrate in the most perfect manner many other affections of the aerial pulses, which we should otherwise conceive very imperfectly. We would recommend to our curious readers to make some of these experiments in a large vessel of milk. Take a long and narrow plate of lead, which, when set on the bottom of the vessel will reach above the surface of the milk; bend this plate into a parabola, elliptical or other curve. Make the undulations by dropping milk on the focus from a small pipe, which will cause the agitations to succeed with rapidity, and then all that we have said will be most distinctly seen, and the experiment will be very amusing and instructive, especially to the musical reader.

339 Caution to the supporters of æthers, animal spirits, &c.

We would now request all who make or read explanations of natural phenomena by means of vibrations of ethers, animal spirits, nervous fluids, &c. to fix their attention on the nature of the agitation in one of these undulations. Let him consider whether this can produce the phenomenon, acting as any matter must act, by impulse or by pressure. If he sees that it can produce the phenomenon, he will be able to point out the very motion it will produce, both in quantity and direction, in the same manner as Sir Isaac Newton has pointed out all the irregularities of the moon's motion produced by the disturbing force of the sun. If he cannot do this, he fails in giving the first evidence of a mechanical explanation by the action of an elastic vibrating fluid. Let him then try to point out some palpable connection between the general phenomena of elastic undulations and the phenomenon in question; this would show an accompaniment to have at least some probability. It is thus only we learn that the undulations of air produce sound: we cannot tell how they affect the mechanism of the ear; but we see that the phenomena of sound always accompany them, and that certain modifications of the one are regularly accompanied by certain modifications of the other. If we cannot do this neither, we have derived neither explanation nor illustration from the elastic fluid. And lastly, let him remember that even if he should be able to show the competency of this fluid to the production of the phenomenon, the whole is still an hypothesis, because we do not know that such a fluid exists.

340 The folly of appealing to such unknown substances.

We will venture to say, that whoever will proceed in this prudent manner will soon see the futility of most of the explanations of this kind which have been given. They are unfit for any but consummate mathematicians; for they alone really understand the mechanism of aerial undulations, and even they speak of them with hesitation as a thing but imperfectly understood. But even the unlearned in this science can see the incompatibility of the hypotheses with many things which they are brought to explain. To take an instance of the conveyance of sensation along the nerves; an elastic fluid is supposed to occupy them, and the undulations of this fluid are thought to be propagated along the nerves. Let us just think a little how the undulations would be conveyed along the surface of a canal which was completely filled up with reeds and bulrushes, or let us make the experiment on such a canal: we may rest assured that the undulations in the one case will resemble those in the other; and we may see that in the canal there will be no regular or sensible propagation of the waves.

Air's Pressure.

Let these observations have their influence, along with others which we have made on other occasions, to wean our readers from this fashionable proneness to introduce invisible fluids and unknown vibrations into our physical discussions. They have done immense, and we fear irreparable, mischief in science; and there is but one phenomenon that has ever received any explanation by their means.

This may suffice for a loose and popular account of aerial undulations; and with it we conclude our account of the motion, impulse, and resistance of air.

We shall now explain a number of natural appearances, depending on its pressure and elasticity, appearances not sufficiently general, or too complicated for the purposes of argument, while we were employed in the investigation of these properties, but too important to be passed over in silence.

341 The air's pressure occasions the cohesion of two surfaces accurately fitting each other;

It is owing to the pressure of the atmosphere that two surfaces which accurately fit each other cohere with such force. This is a fact familiarly known to the glass-grinders, polishers of marble, &c. A large lense or speculum, ground on its tool till it becomes very smooth, requires more than any man's strength to separate it directly from the tool. If the surface is only a square inch, it will require 15 pounds to separate them perpendicularly, though a very moderate force will make them slide along each other. But this cohesion is not observed unless the surfaces are wetted or smeared with oil or grease; otherwise the air gets between them, and they separate without any trouble. That this cohesion is owing to the atmospheric pressure, is evident from the ease with which the plates may be separated in an exhausted receiver.

342 and the adhesion of snails, &c. to rocks.

To the same cause we must ascribe the very strong adhesion of snails, periwinkles, limpets, and other univalve shells, to the rocks. The animal forms the rim of its shell, so as to fit the shape of the rock to which it intends to cling. It then fills its shell (if not already filled by its own body) with water. In this condition it is evident that we must act with a force equal to 15 pounds for every square inch of touching surface before we can detach it. This may be illustrated by filling a drinking glass to the brim with water; and having covered it with a piece of thin wet leather, whelm it on a table, and then try to pull it straight up; it will require a considerable force. But if we expose a snail adhering to a stone in the exhausted receiver, we shall see it drop off by its own weight. In the same manner do the remora, the polypus, the lamprey, and many other animals, adhere with such firmness. Boys frequently amuse themselves by pulling out large stones from the pavement by means of a circle of stiff wetted leather fastened to a string. It is owing to the same cause that the bivalve shell fishes keep themselves so firmly shut. We think the muscular force of an oyster prodigious, because it requires such force to open it; but if we grind off a bit of the convex shell, so as to make a hole in it, though without hurting the fish in the smallest

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est degree, it opens with great ease, as it does also *in vacuo*.

343 Other effects of the air's pressure.

The pressure of the air, operating in this way, contributes much to the cohesion of bodies, where we do not suspect its influence. The tenacity of our mortars and cements would frequently be ineffectual without this assistance.

It is owing to the pressure of the atmosphere that a cask will not run by the cock unless a hole be opened in some other part of the cask. If the cask is not quite full, some liquor indeed will run out, but it will stop as soon as the diminished elasticity of the air above the liquor is in equilibrio (together with the liquor) with the atmospheric pressure. In like manner, a teapot must have a small hole in its lid to ensure its pouring out the tea. If indeed the hole in the cask is of large dimensions, it will run without any other hole, because air will get in at the upper side of the hole while the liquor runs out by the lower part of it.

On the same principle depends the performance of an instrument used by the spirit dealers for taking out a sample of their spirits. It consists of a long tinplate tube AB (fig. 74.), open a-top at A, and ending in a small hole at B. The end B is dipped into the spirits, which rises into the tube; then the thumb is clapt on the mouth A, and the whole is lifted out of the cask. The spirit remains in it till the thumb be taken off; it is then allowed to run into a glass for examination.

Plate cccccxxxi. fig. 74.

344 Why frosts instantly occasion a scarcity of water.

It seems principally owing to the pressure of the air that frosts immediately occasion a scantiness of water in our fountains and wells. This is erroneously accounted for, by supposing that the water freezes in the bowels of the earth. But this is a great mistake: the most intense frost of a Siberian winter would not freeze the ground two feet deep; but a very moderate frost will consolidate the whole surface of a country, and make it impervious to the air; especially if the frost has been preceded by rain, which has soaked the surface. When this happens, the water which was filtering through the ground is all arrested and kept suspended in its capillary tubes by the pressure of the air, in the very same manner as the spirits are kept suspended in the instrument just now described by the thumb's shutting the hole A. A thaw melts the superficial ice, and allows the water to run in the same manner as the spirits run when the thumb is removed.

345 The necessity of common air to anima life.

Common air is necessary for supporting the lives of most animals. If a small animal, such as a mouse or bird, be put under the receiver of an air-pump, and the air be exhausted, the animal will quickly be thrown into convulsions and fall down dead; if the air be immediately readmitted, the animal will sometimes revive, especially if the rarefaction has been briskly made, and has not been very great. We do not know that any breathing animal can bear the air to be reduced to one-fourth of its ordinary density, nor even one-third; nor have we good evidence that an animal will ever recover if the rarefaction is pushed very far, although continued for a very short time.

But the mere presence of the air is by no means sufficient for preserving the life of the animal; for it is found, that an animal shut up in a vessel of air cannot live in it for any length of time. If a man be shut up in a box, containing a wine hogshead of air, he cannot live in it much above an hour, and long before this he will find his breathing very unsatisfactory and uneasy. A gallon of air will support him about a minute. A box EF (fig. 75.) may be made, having a pipe AB inserted into its top, and fitted with a very light valve at B, opening upwards. This pipe sends off a lateral branch *a* D *d* C, which enters the box at the bottom, and is also fitted with a light valve at C opening upwards. If a person breathe through the pipe, keeping his nostrils shut, it is evident that the air which he expires will not enter the box by the hole B, nor return through the pipe CD *d;* and by this contrivance he will gradually employ the whole air of the box. With this apparatus experiments can be made without any risk or inconveniency, and the quantity of air necessary for a given time of easy breathing may be accurately ascertained.

Effects of Air's pressure. Fig. 75.

How the air of our atmosphere produces this effect, is a question which does not belong to mechanical philosophy to investigate or determine. We can, however, affirm, that it is neither the pressure nor the elasticity of the air which is immediately concerned in maintaining the animal functions. We know that we can live and breathe with perfect freedom on the tops of the highest mountains. The valley of Quito in Peru, and the country round Gondar in Abyssinia, are so far elevated above the surface of the ocean, that the pressure and the elasticity of the air are one-third less than in the low countries; yet these are populous and healthy places. And, on the other hand, we know, that when an animal has breathed in any quantity of air for a certain time without renewal, it will not only be suffocated, but another animal put into this air will die immediately; and we do not find either the pressure or elasticity of the air remarkably diminished: it is indeed diminished, but by a very small quantity. Restoring the former pressure and elasticity has not the smallest tendency to prevent the death of the animal: for an animal will live no longer under a receiver that has its mouth inverted on water, than in one set upon the pump-plate covered with leather. Now when the receiver is set on water, the pressure of the atmosphere acts completely on the included air, and preserves it in the same state of elasticity.

346 The nature of air when it has maintained animal functions is quite altered.

In short, it is known that the air which has already served to maintain the animal functions has its chemical and alimentary properties completely changed, and is no longer fit for this purpose. So much of any mass of air as has really been thus employed is changed into what is called *fixed air* by Dr Black, or *carbonic acid* by the chemists of the Lavoisierian school. Any person may be convinced of this by breathing or blowing through a pipe immersed in lime water. Every expiration will produce white clouds on the water, till all the lime which it contains is precipitated in the form of pure chalk. In this case we know that the lime has combined with the fixed air.

347 Hales's experiments to restore its former qualities, &c.

The celebrated Dr Stephen Hales made many experiments, with a view to clear the air from the noxious vapour which he supposed to be emitted from the lungs.

He made use of the apparatus which we have been just now mentioning; and he put several diaphragms *ff*, *ff*, &c. of thin woollen stuff into the box, and moistened them with various liquids. He found nothing so efficacious as a solution of potash. We now understand

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stand this perfectly. If the solution is not already saturated with fixed air, it will take it up as fast as it is produced, and thus will purify the air: a solution of caustic alkali therefore will have this effect till it is rendered quite mild.

348 How it comes to be changed by breathing, and the nature of inspiration, &c.

These experiments have been repeated, and varied in many circumstances, in order to ascertain whether this fixed air was really emitted by the lungs, or whether the inspired air was in part changed into fixed air by its combination with some other substance. This is a question which comes properly in our way, and which the doctrines of pneumatics enable us to answer. If the fixed air be emitted in substance from the lungs, it does not appear how a renewal of the air into which it is emitted is necessary: for this does not hinder the subsequent emission; and the bulk of the air would be increased by breathing in it, viz. by the bulk of all the fixed air emitted; but, on the contrary, it is a little diminished. We must therefore adopt the other opinion; and the discoveries in modern chemistry enable us to give a pretty accurate account of the whole process. Fixed air is acknowledged to be a compound, of which one ingredient is found to constitute about three-eighths of the whole atmospheric fluid; we mean vital air or the oxygen of Lavoisier. When this is combined with phlogiston, according to the doctrine of Stahl, or with charcoal, according to Lavoisier, the result is fixed air or carbonic acid. The change therefore which breathing makes on the air is the solution of this matter by vital air; and the use of air in breathing is the carrying off this noxious principle in the way of solution. When therefore the air is already so far saturated as not to dissolve this substance as fast as it is secreted, or must be secreted in the lungs, the animal suffers the pain of suffocation, or is otherwise mortally affected. Suffocation is not the only consequence; for we can remain for a number of seconds without breathing, and then we begin to feel the true pain of suffocation; but those who have been instantaneously struck down by an inspiration of fixed air, and afterwards recovered to life, complained of no such pain, and seemed to have suffered chiefly by a nervous affection. It is said (but we will not vouch for the truth of it), that a person may safely take a full inspiration of fixed air, if the passages of the nose be shut; and that unless these nerves are stimulated by the fixed air, it is not instantaneously mortal. But these are questions out of our present line of inquiry. They are questions of physiology, and are treated of in other places of this work. See ANATOMY and PHYSIOLOGY; see also LUNGS and RESPIRATION. Our business is to explain in what manner the pressure and elasticity of the air, combined with the structure and mechanism of the body, operate in producing this necessary secretion and removal of the matter discharged from the lungs in the act of breathing.

It is well ascertained, that the secretion is made from the mass of blood during its passage through the lungs. The blood delivered into the lungs is of a dark blackish colour, and is there changed into a florid red. In the lungs it is exposed to the action of the air in a prodigiously extended surface: for the lungs consist of an inconceivable number of small vessels or bladders, communicating with each other and with the windpipe. These are filled with air in every inspiration. These vessels are everywhere in contact with minute blood-vessels. The blood does not *in toto* come into immediate contact with the air; and it would seem that it is only the thin serous part of it which is acted on by the air at the mouths of the vessels or pores, where it stands by capillary attraction. Dr Priestley found, that venous blood inclosed in thin bladders and other membranes was rendered florid by keeping the bladders in contact with abundance of pure vital air. We know also, that breath is moist or damp, and *must* have acquired this moisture in the lungs. It is immaterial whether this secretion of water or lymph (as the anatomists call it) be furnished by mere exudation through simple pores, or by a vascular and organic secretion; in either case, some ingredient of the blood comes in contact with air in the lungs, and there unites with it. This is farther confirmed, by observing, that all breathing animals are warmer than the surrounding medium, and that by every process in which fixed air is formed from vital air heat is produced. Hence this solution in air of something from the blood has been assigned by many as the source of animal heat. We touch on these things in a very transitory way in this place, only in order to prove that, for the support of animal life, there must be a very extensive application of air to the blood, and that this is made in the lungs.

The question before us in this place is, How is this brought about by the weight and elasticity of the air? This is done in two ways; by the action of the muscles of the ribs, and by the action of the diaphragm and other muscles of the abdomen. The thorax or chest is a great cavity, completely filled by the lungs. The sides of this cavity are formed by the ribs. These are crooked or arched, and each is moveable round its two ends, one of them being inserted into the vertebræ of the back, and the other into the sternum or breast-bone. The rib turns in a manner resembling the handle of a drawer. The inspection of fig. 76. will illustrate this matter a little. Suppose the curves *a c e*, *b k f*, *c l g*, &c. to represent the ribs moveable round the extremities. Each succeeding rib is more bent than the one above it, and this curvature is both in the vertical and horizontal direction. Suppose each so broad as to project a little over its inferior like the tiles of a roof. It is evident, that if we take the lower one by its middle, and draw it out a little, moving it round the line *n p*, it will bring out the next *d m h* along with it. Also, because the distance of the middle point *o* from the axis of motion *n p* is greater than the distance of *m* from the axis *d h*, and because *o* will therefore describe a portion of a larger circle than *m* does, the rib *n o p* will slide up a little under the rib *d m h*, or the rib *d m h* will overlap *n o p* a little more than before; the distance *o m* will therefore be diminished. The same must happen to all the superior ribs; but the change of distance will be less and less as we go upwards. Now, instead of this great breadth of the ribs overlapping each other, suppose each inferior rib connected with the one above it by threads or fibres susceptible of contraction at the will of man. The articulations *e*, *a*, of the first or upper rib with the spine and sternum are so broad and firm, that this rib can have little or no motion round the line *a e*; this rib therefore is as a fixture for the ends of all the contracting fibres: therefore, whenever the fibres which connect the second rib with the first rib contract, the second must rise a little, and also go outward, and will carry the lower ribs

Fig. 76.

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ribs along with it; the third rib will rise still farther by the contraction of the muscles which connect it with the second, and so on: and thus the whole ribs are raised and thrown outward (and a little forward, because the articulation of each with the spine is considerably higher than that with the sternum), and the capacity of the thorax is enlarged by the contraction of its muscular covering. The direction of the muscular fibres is very oblique to the direction of the circular motion which it produces; from which circumstance it follows, that a very minute contraction of the muscles produces all the motion which is necessary. This indeed is not great; the whole motion of the lowest ribs is less than an inch in the most violent inspiration, and the whole contraction of the muscles of the twelve ribs does not exceed the eighth part of an inch, even supposing the intercostal muscles at right angles to the ribs; and being oblique, the contraction is still less (see BORELLI, SABATIER, MONRO, &c.). It would seem, that the intensity of the contractive power of a muscular fibre is easily obtained, but that the space through which it can be exerted is very limited; for in most cases nature places the muscles in situations of great mechanical disadvantage in this respect, in order to procure other conveniences.

But this is not the whole effect of the contraction of the intercostal muscles: since the compound action of the two sets of muscles, which cross each other from rib to rib like the letter X, is nearly at right angles to the rib, but is oblique to its plane, it tends to push the ribs closer on their articulations, and thus to press out the two pillars on which they are articulated. Thus, supposing *a f* (fig. 77.) to represent the section of one of the vertebræ of the spine, and *c d* a section of the sternum, and *a b c*, *f e d*, two opposite ribs, with a lax thread *b e* connecting them. If this thread be pulled upwards by the middle *g* till it is tight, it will tend to pull the points *b* and *e* nearer to each other, and to press the vertebra *a f* and the sternum *c d* outwards. The spine being the chief pillar of the body, may be considered as immoveable in the present instance. The sternum is sufficiently susceptible of motion for the present purpose. It remains almost fixed a-top at its articulation with the first rib, but it gradually yields below; and thus the capacity of the thorax is enlarged in this direction also. The whole enlargement of the diameters of the thorax during inspiration is very small, not exceeding the fiftieth part of an inch in ordinary cases. This is easily calculated. Its quiescent capacity is about two cubic feet, and we never draw in more than 15 inches. Two spheres, one of which holds 2 cubic feet and the other 2 feet and 15 inches, will not differ in diameter above the fiftieth part of an inch.

Fig. 77.

The other method of enlarging the capacity of the thorax is very different. It is separated from the abdomen by a strong muscular partition called the *diaphragm*, which is attached to firm parts all around. In its quiescent or relaxed state it is considerably convex upwards, that is, towards the thorax, rising up into its cavity like the bottom of an ordinary quart bottle, only not so regular in its shape. Many of its fibres tend from its middle to the circumference, where they are inserted into firm parts of the body. Now suppose these fibres to contract. This must draw down its middle, or make it flatter than before, and thus enlarge the capacity of the thorax.

Physiologists are not well agreed as to the share which each of these actions has in the operation of enlarging the thorax. Many refuse all share of it to the intercostal muscles, and say that it is performed by the diaphragm alone. But the fact is, that the ribs are really observed to rise even while the person is asleep; and this cannot possibly be produced by the diaphragm, as these anatomists assert. Such an opinion shows either ignorance or neglect of the laws of pneumatics. If the capacity of the thorax were enlarged only by drawing down the diaphragm, the pressure of the air would compress the ribs, and make them descend. And the simple laws of mechanics make it as evident as any proposition in geometry, that the contraction of the intercostal muscles *must* produce an elevation of the ribs and enlargement of the thorax; and it is one of the most beautiful contrivances of nature. It depends much on the will of the animal what share each of these actions shall have. In general, the greatest part is done by the diaphragm; and any person can breathe in such a manner that his rib shall remain motionless; and, on the contrary, he can breathe almost entirely by raising his chest. In the first method of breathing, the belly rises during inspiration, because the contraction of the diaphragm compresses the upper part of the bowels, and therefore squeezes them outwards; so that an ignorant person would be apt to think that the breathing was performed by the belly, and that the belly is inflated with the air. The strait lacing of the women impedes the motion of the ribs, and changes the natural habit of breathing, or brings on an unnatural habit. When the mind is depressed, it is observed that the breathing is more performed by the muscles of the thorax; and a deep sigh is always made in this way.

These observations on the manner in which the capacity of the chest can be enlarged were necessary, before we can acquire a just notion of the way in which the mechanical properties of air operate in applying it to the mass of blood during its passage through the lungs. Suppose the thorax quite empty, and communicating with the external air by means of the trachea or windpipe, it would then resemble a pair of bellows. Raising the boards corresponds to the raising of the ribs; and we might imitate the action of the diaphragm by forcibly pulling outwards the folded leather which unites them. Thus their capacity is enlarged, and the air rushes in at the nozzle by its weight in the same manner as water would do. The thorax differs from bellows only in this respect, that it is filled by the lungs, which is a vast collection of little bladders, like the holes in a piece of fermented bread, all communicating with the trachea, and many of them with each other. When the chest is enlarged, the air rushes into them all in the same manner as into the single cavity of an empty thorax. It cannot be said with propriety that they are inflated: all that is done is the *allowing* the air to come in. At the same time, as their membranous covering must have some thickness, however small, and some elasticity, it is not unlikely that, when compressed by expiration, they tend a little to recover their former shape, and thus aid the voluntary action of the muscles. It is in this manner that a small bladder of caoutchouc swells

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swells again after compression, and fills itself with air or water. But this cannot happen except in the most minute vesicles: those of sensible bulk have not elasticity enough for this purpose. The lungs of birds, however, have some very large bladders, which have a very considerable elasticity, and recover their shape and size with great force after compression, and thus fill themselves with air. The respiration of these animals is considerably different from that of land animals, and their muscles act chiefly in expiration. This will be explained by and by as a curious variety in the pneumatic instrument.

This account of the manner in which the lungs are filled with air does not seem agreeable to the notions

349 We take in air not by our own action, but by external pressure.

we entertain of it. We seem to suck in the air; but although it be true that we act, and exert force, in order to get air into our lungs, it is not by our action, but by external pressure, that it does come in. If we apply our mouth to the top of a bottle filled with water, we find that no draught, as we call it, of our chest will suck in any of the water; but if we suck in the very same manner at the end of a pipe immersed in water, it follows immediately. Our interest in the thing makes us connect in imagination our own action with the effect, without thinking on the many steps which may intervene in the train of natural operations; and we consider the action as the immediate cause of the air's reception into the lungs. It is as if we opened the door, and took in by the hand a person who was really pushed in by the crowd without. If an incision be made into the side of the thorax, so that the air can get in by that way, when the animal acts in the usual manner, the air will really come in by this hole, and fill the space between the lungs and the thorax; but no air is sucked into the lungs by this process, and the animal is as completely suffocated as if the windpipe were shut up. And, on the other hand, if a hole be made into the lungs without communicating with the thorax, the animal will breathe through this hole, though the windpipe be stopped. This is successfully performed in cases of patients whose trachea is shut up by accident or by inflammation; only it is necessary that this perforation be made into a part of the lungs where it may meet with some of the great pulmonary passages: for if made into some remote part of a lobe, the air cannot find its way into the rest of the lungs through such narrow passages, obstructed too by blood, &c.

350 Nature of expiration.

We have now explained, on pneumatical principles, the process of inspiration. The expiration is chiefly performed by the natural tone of the parts. In the act of inspiration the ribs were raised and drawn outwards in opposition to the elasticity of the solids themselves; for although the ribs are articulated at their extremities, the articulations are by no means such as to give a free and easy motion like the joints of the limbs. This is particularly the case in the articulations with the sternum, which are by no means fitted for motion. It would seem that the motion really produced here is chiefly by the yielding of the cartilaginous parts and the bending of the rib; when therefore the muscles which produced this effect are allowed to relax, the ribs again collapse. Perhaps this is assisted a little by the action of the long muscles which come down across the ribs without being inserted into them. These may draw them together a little, as we compress a loose bundle by a string.

In like manner, when the diaphragm was drawn down, it compressed the abdomen in opposition to the elasticity of all the viscera contained in it, and to the elasticity and tone of the teguments and muscles which surround it. When therefore the diaphragm is relaxed, these parts push it up again into its natural situation, and in doing this expel the air from the lungs.

351 It requires no effort.

If this be a just account of the matter, expiration should be performed without any effort. This accordingly is the case. We feel that, after having made an ordinary easy inspiration, it requires the continuance of the effort to keep the thorax in this enlarged state, and that all that is necessary for expiration is to cease to act. No person feels any difficulty in emptying the lungs; but weak people often feel a difficulty of inspiration, and compare it to the feeling of a weight on their breast; and expiration is the last motion of the thorax in a dying person.

But nature has also given us a mechanism by which we can expire, namely, the abdominal muscles; and when we have finished an ordinary and easy expiration, we can still expel a considerable bulk of air (nearly half of the contents of the lungs) by contracting the abdominal muscles. These, by compressing the body, force up its moveable contents against the diaphragm, and cause it to rise further into the thorax, acting in the same manner as when we expel the fæces *per anum*. When a person breathes out as much air as he can in this manner, he may observe that his ribs do not collapse during the whole operation.

352 A certain quantity of air necessary to keep the lungs of a natural size.

There seems then to be a certain natural unconstrained state of the vesicles of the lungs, and a certain quantity of air necessary for keeping them of this size. It is probable that this state of the lungs gives the freest motion to the blood. Were they more compressed, the blood vessels would be compressed by the adjoining vesicles; were they more lax, the vessels would be more crooked, and by this means obstructed. The frequent inspirations gradually change this air by mixing fresh air with it, and, at every expiration carrying off some of it. In catarrhs and inflammations, especially when attended with suppuration, the small passages into the remote vessels are obstructed, and thus the renewal of air in them will be prevented. The painful feeling which this occasions causes us to expel the air with violence, shutting the windpipe, till we have exerted strongly with the abdominal muscles, and made a strong compression on the lower part of the thorax. We then open the passage suddenly, and expel the air and obstructing matter by violent coughing.

353 Process of breathing in birds.

We have said, that birds exhibit a curious variety in the process of breathing. The muscles of their wings being so very great, required a very extensive insertion, and this is one use of the great breast-bone. Another use of it is, to form a firm partition to hinder the action of these muscles from compressing the thorax in the act of flying: therefore the form of their chest does not admit of alternate enlargement and contraction to that degree as in land animals. Moreover, the muscles of their abdomen are also very small; and it would seem that they are not sufficient for producing the compression on the bowels which is necessary for carrying

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carrying on the process of concoction and digestion. Instead of aiding the lungs, they receive help from them.

Fig. 78. In an ostrich, the lungs consist of a fleshy part A, A (fig. 78.), composed of vesicles like those of land animals, and, like theirs, serving to expose the blood to the action of the air. Besides these, they have on each side four large bags B, C, D, E, each of which has an orifice G communicating with the trachea; but the second, C, has also an orifice H, by which it communicates with another bag F situated below the rest in the abdomen. Now, when the lungs are compressed by the action of the diaphragm, the air in C is partly expelled by the trachea through the orifice G, and partly driven through the orifice H into the bag F, which is then allowed to receive it; because the same action which compresses the lungs enlarges the abdomen. When the thorax is enlarged, the bag C is partly supplied with fresh air through the trachea, and partly from the bag F. As the lungs of other animals resemble a common bellows, the lungs of birds resemble the smith's bellows with a partition; and anatomists have discovered passages from this part of the lungs into their hollow bones and quills. We do not know all the uses of this contrivance; and only can observe, that this alternate action must assist the muscles of the abdomen in promoting the motion of the food along the alimentary canal, &c. We can distinctly observe in birds that their belly dilates when the chest collapses, and *vice versa*, contrary to what we see in the land animals. Another use of this double passage may be to produce a circulation of air in the lungs, by which a compensation is made for the smaller surface of action on the blood: for the number of small vesicles, of equal capacity with these large bags, gives a much more extensive surface.

If we try to raise mercury in a pipe by the action of the chest alone, we cannot raise it above two or three inches; and the attempt is both painful and hazardous. It is painful chiefly in the breast, and it provokes coughing. Probably the fluids ooze through the pores of the vesicles by the pressure of the surrounding parts.

On the other hand, we can by expiration support mercury about five or six inches high: but this also is very painful, and apt to produce extravasation of blood. This seems to be done entirely by the abdominal muscles.

354 The operation of sucking,

The operation properly termed SUCKING is totally different from breathing, and resembles exceedingly the action of a common pump. Suppose a pipe held in the mouth, and its lower end immersed in water. We fill the mouth with the tongue, bringing it forward, and applying it closely to the teeth and to the palate; we then draw it back, or bend it downwards (behind) from the palate, thus leaving a void. The pressure of the air on the cheeks immediately depresses them, and applies them close to the gums and teeth; and its pressure on the water in the vessel causes it to rise through the pipe into the empty part of the mouth, which it quickly fills. We then push forward the tip of the tongue, below the water, to the teeth, and apply it to them all round, the water being above the tongue, which is kept much depressed. We then apply the tongue to the palate, beginning at the tip, and gradually going backwards in this application. By this means the water is gradually forced backward by an operation similar to that of the gullet in swallowing. This is done by contracting the gullet above and relaxing it below, just as we would empty a gut of its contents by drawing our closed hand along it. By this operation the mouth is again completely occupied by the tongue, and we are ready for repeating the operation. Thus the mouth and tongue resemble the barrel and piston of a pump; and the application of the tip of the tongue to the teeth performs the office of the valve at the bottom of the barrel, preventing the return of the water into the pipe. Although usual, it is not absolutely necessary, to withdraw the tip of the tongue, making a void before the tongue. Sucking may be performed by merely separating the tongue gradually from the palate, beginning at the root. If we withdraw the tip of the tongue a very minute quantity, the water gets in and flows back above the tongue.

The action of the tongue in this operation is very powerful; some persons can raise mercury 25 inches: but this strong exertion is very fatiguing, and the soft parts are prodigiously swelled by it. It causes the blood to ooze plentifully through the pores of the tongue, fauces, and palate, in the same manner as if a cupping-glass and syringe were applied to them; and, when the inside of the mouth is excoriated or tender, as is frequent with infants, even a very moderate exertion of this kind is accompanied with extravasation of blood. When children suck the nurse's breast, the milk follows their exertion by the pressure of the air on the breast; and a weak child, or one that withholds its exertions on account of pain from the above-mentioned cause, may be assisted by a gentle pressure of the hand on the breast: the infant pupil of nature, without any knowledge of pneumatics, frequently helps itself by pressing its face to the yielding breast.

In the whole of this operation the breathing is performed through the nostrils; and it is a prodigious distress to an infant when this passage is obstructed by mucus. We beg to be forgiven for observing by the way, that this obstruction may be almost certainly removed for a little while, by rubbing the child's nose with any liquid of quick evaporation, or even with water.

The operation in drinking is not very different from that in sucking: we have indeed little occasion here to suck, but we must do it a little. Dogs and some other animals cannot drink, but only lap the water into their mouths with their tongue, and then swallow it. The gallinaceous birds seem to drink very imperfectly; they seem merely to dip their head into the water up to the eyes till their mouth is filled with water, and then holding up the head, it gets into the gullet by its weight, and is then swallowed. The elephant drinks in a very complicated manner; he dips his trunk into the water, and fills it by making a void in his mouth: this he does in the contrary way to man. After having depressed his tongue, he begins the application of it to the palate at the root, and by extending the application forward, he expels the air by the mouth which came into it from the trunk. The process here is not very unlike that of the condensing syringe without a piston valve, described in N° 58. in which the external air (corresponding here to the air in the trunk) enters by the hole F in the side, and is expelled through the hole in the end of the barrel; by this operation the trunk is filled with water; then he lifts his trunk out of the water, and bringing it to his mouth, pours the contents into it, and swallows it. On considering this operation, it appears that, by the

355 and of drinking, which is very similar.

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the same process by which the air of the trunk is taken into the mouth, the water could also be taken in, to be afterwards swallowed: but we do not find, upon inquiry, that this is done by the elephant; we have always observed him to drink in the manner now described. In either way it is a double operation, and cannot be carried on any way but by alternately sucking and swallowing, and while one operation is going on the other is interrupted; whereas man can do both at the same time. Nature seems to delight in exhibiting to rational observers her inexhaustible variety of resource; for many insects, which drink with a trunk, drink without interruption: yet we do not call in question the truth of the aphorism, *Natura maxime simplex et semper sibi consona*, nor doubt but that, if the *whole* of her purpose were seen, we should find that her process is the simplest possible: for Nature, or Nature's God, is wise above our wisest thoughts, and simplicity is certainly the choice of wisdom: but alas! it is generally but a small and the most obvious part of her purpose that we can observe or appreciate. We seldom see this simplicity of nature stated to us, except by some system-maker, who has found a principle which somehow tallies with a considerable variety of phenomena, and then cries out, *Frustra fit per plura quod fieri potest per pauciora.*

356 Mode of keeping up a continued blast with a blow-pipe.

There is an operation similar to that of the elephant, which many find a great difficulty in acquiring, viz. keeping up a continued blast with a blow-pipe. We would desire our chemical reader to attend minutely to the gradual action of his tongue in sucking, and he will find it such as we have described. Let him attend particularly to the way in which the tip of the tongue performs the office of a valve, preventing the return of the water into the pipe: the same position of the tongue would hinder air from coming into the mouth. Next let him observe, that in swallowing what water he has now got lodged above his tongue, he continues the tip of the tongue applied to the teeth; now let him shut his mouth, keeping his lips firm together, the tip of the tongue at the teeth, and the whole tongue forcibly kept at a distance from the palate; bring up the tongue to the palate, and allow the tip to separate a little from the teeth, this will expel the air into the space between the fauces and cheeks, and will blow up the cheeks a little: then, acting with the tip of the tongue as a valve, hinder this air from getting back, and depressing the tongue again, more air (from the nostrils) will get into the mouth, which may be expelled into the space without the teeth as before, and the cheeks will be more inflated: continue this operation, and the lips will no longer be able to retain it, and it will ooze through as long as the operation is continued. When this has become familiar and easy, take the blow-pipe, and there will be no difficulty in maintaining a blast as uniform as a smith's bellows, breathing all the while through the nostrils. The only difficulty is the holding the pipe: this fatigues the lips; but it may be removed by giving the pipe a convenient shape, a pretty flat oval, and wrapping it round with leather or thread.

357 Nature of the land and sea breeze in warm countries.

Another phenomenon depending on the principles already established, is the land and sea-breeze in the warm countries.

We have seen that air expands exceedingly by heat; therefore heated air, being lighter than an equal bulk of cold air, must rise in it. If we lay a hot stone in the sunshine in a room, we shall observe the shadow of the stone surrounded with a fluttering shadow of different degrees of brightness, and that this flutter rises rapidly in a column above the stone. If we hold an extinguished candle near the stone, we shall see the smoke move towards the stone, and then ascend from it. Now, suppose an island receiving the first rays of the sun in a perfectly calm morning; the ground will soon be warmed, and will warm the contiguous air. If the island be mountainous, this effect will be more remarkable; because the inclined sides of the hills will receive the light more directly: the midland air will therefore be most warmed: the heated air will rise, and that in the middle will rise fastest; and thus a current of air upwards will begin, which must be supplied by air coming in from all sides, to be heated and to rise in its turn; and thus the morning *sea-breeze* is produced, and continues all day. This current will frequently be reversed during the night, by the air cooling and gliding down the sides of the hills, and we shall have the *land-breeze*.

358 Circulation of air in mines.

It is owing to the same cause that we have a circulation of air in mines which have the mouths of their shafts of unequal heights. The temperature under ground is pretty constant through the whole year, while that of the atmosphere is extremely variable. Now, suppose a mine having a long horizontal drift, communicating between two pits or shafts, and that one of these shafts terminates in a valley, while the other opens on the brow of a hill perhaps 100 feet higher. Let us further suppose it summer, and the air heated to 65°, while the temperature of the earth is but 45°; this last will be also the temperature of the air in the shafts and the drift. Now, since air expands nearly 24 parts in 10,000 by one degree of heat, we shall have an odds of pressure at the bottom of the two shafts equal to nearly the 20th part of the weight of a column of air 100 feet high (100 feet being supposed the difference of the heights of the shafts). This will be about six ounces on every square foot of the section of the shaft. If this pressure could be continued, it would produce a prodigious current of air down the long shafts, along the drift, and up the short shaft. The weight of the air acting through 100 feet would communicate to it the velocity of 80 feet per second: divide this by $\sqrt{20}$, that is, by 4.5, and we shall have 18 feet per second for the velocity: this is the velocity of what is called a brisk gale. This pressure *would* be continued, if the warm air which enters the long shaft were cooled and condensed as fast as it comes in; but this is not the case. *It is however cooled* and condensed, and a current is produced sufficient to make an abundant circulation of air along the whole passage; and care is taken to dispose the shafts and conduct the passages in such a manner that no part of the mine is out of the circle. When any new lateral drift is made, the renewal of air at its extremity becomes more imperfect as it advances: and when it is carried a certain length, the air stagnates and becomes suffocating, till either a communication can be made with the rest of the mine, or a shaft be made at the end of this drift.

As this current depends entirely on the difference of temperature between the air below and that above, it must cease when this difference ceases. Accordingly, in the spring and autumn, the miners complain much of stagnation: but in summer they never want a current from the deep pits to the shallow, nor in the winter a

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a current from the shallow pits to the deep ones. It frequently happens also, that in mineral countries the chemical changes which are going on in different parts of the earth make differences of temperature sufficient to produce a sensible current.

It is easy to see that the same causes must produce a current down our chimneys in summer. The chimney is colder than the summer air, and must therefore condense it, and it will come down and run out at the doors and windows.

359 The nature of what is called the draught in chimneys.

And this naturally leads us to consider a very important effect of the expansion and consequent ascent of air by heat, namely the drawing (as it is called) of chimneys. The air which has contributed to the burning of fuel must be intensely heated, and will rise in the atmosphere. This will also be the case with much of the surrounding air which has come very near the fire, although not in contact with it. If this heated air be made to rise in a pipe, it will be kept together, and therefore will not soon cool and collapse: thus we shall obtain a long column of light air, which will rise with a force so much the greater as the column is longer or more heated. Therefore the taller we make the chimney, or the hotter we make the fire, the more rapid will be the current, or the draught or suction, as it is injudiciously called, will be so much the greater. The ascensional force is the difference between the weight of the column of heated air in the funnel and a column of the surrounding atmosphere of equal height. We increase the draught, therefore, by increasing the perpendicular height of the chimney. Its length in a horizontal direction gives no increase, but, on the contrary, diminishes the draught by cooling the air before it gets into the effective part of the funnel. We increase the draught also by obliging all the air which enters the chimney to come very near the fuel; therefore a low mantle-piece will produce this effect; also filling up all the spaces on each side of the grate. When much air gets in above the fire, by having a lofty mantle-piece, the general mass of air in the chimney cannot be much heated. Hence it must happen that the greatest draught will be produced by bringing down the mantle-piece to the very fuel; but this converts a fire-place into a furnace, and by thus sending the whole air through the fuel, causes it to burn with great rapidity, producing a prodigious heat; and this producing an increase of ascensional force, the current becomes furiously rapid, and the heat and consumption of fuel immense. If the fire-place be a cube of a foot and a half, and the front closed by a door, so that all the air must enter through the bottom of the grate, a chimney of 15 or 20 feet high, and sufficiently wide to give passage to all the expanded air which can pass through the fire, will produce a current which will roar like thunder, and a heat sufficient to run the whole inside into a lump of glass.

All that is necessary, however, in a chamber fire-place, is a current sufficiently great for carrying up the smoke and vitiated air of the fuel. And as we want also the enlivening flutter and light of the fire, we give the chimney-piece both a much great height and width than what is merely necessary for carrying up the smoke, only wishing to have the current sufficiently determinate and steady for counteracting any occasional tendency which it may sometimes have to come into the room. By allowing a greater quantity of air to get into the chimney, heated only to a moderate degree, we produce a more rapid renewal of the air of the room: did we oblige it to come so much nearer the fire as to produce the same renewal of the air in consequence of a more rapid current, we should produce an inconvenient heat. But in this country, where pit-coal is in general so very cheap, we carry this indulgence to an extreme; or rather we have not studied how to get all the desired advantages with economy. A much smaller renewal of air than we commonly produce is abundantly wholesome and pleasant, and we may have all the pleasure of the light and flame of the fuel at much less expence, by contracting greatly the passage into the vent. The best way of doing this is by contracting the brick-work on each side behind the mantle-piece, and reducing it to a narrow parallelogram, having the back of the vent for one of its long sides. Make an iron plate to fit this hole, of the same length, but broader, so that it may lie sloping, its lower edge being in contact with the foreside of the hole, and its upper edge leaning on the back of the vent. In this position it shuts the hole entirely. Now let the plate have a hinge along the front or lower edge, and fold up like the lid of a chest. We shall thus be able to enlarge the passage at pleasure. In a fire-place fit for a room of 24 feet by 18, if this plate may be about 18 inches long from side to side, and folded back within an inch or an inch and a half of the wall, this will allow passage for as much air as will keep up a very cheerful fire: and by raising or lowering this REGISTER, the fire may be made to burn more or less rapidly. A free passage of half an inch will be sufficient in weather that is not immoderately cold. The principle on which this construction produces its effect is, that the air which is in the front of the fire, and much warmed by it, is not allowed to get into the chimney, where it would be immediately hurried up the vent, but rises up to the ceiling and is diffused over the whole room. This double motion of the air may be distinctly observed by opening a little of the door and holding a candle in the way. If the candle be held near the floor, the flame will be blown into the room; but if held near the top of the door, the flame will be blown outward.

360 Description of a stove-grate or chapelle.

But the most perfect method of warming an apartment in the temperate climates, where we can indulge in the cheerfulness and sweet air produced by an open fire, is what we call a stove-grate, and our neighbours on the continent call a chapelle, from its resemblance to the chapels or oratories in the great churches.

In the great chimney-piece, which, in this case, may be made even larger than ordinary, is set a smaller one fitted up in the same stile of ornament, but of a size no greater than is sufficient for holding the fuel. The sides and back of it are made of iron (cast iron is preferable to hammered iron, because it does not so readily calcine), and are kept at a small distance from the sides and back of the main chimney-piece, and are continued down to the hearth, so that the ash-pit is also separated. The pipe or chimney of the stove grate is carried up behind the ornaments of the mantle-piece till it rises above the mantle-piece of the main chimney-piece, and is fitted with a register or damper-plate turning round a traverse axis. The best form of this register is that which we have recommended for an ordinary fire-place, having its axis or joint close at the front; so that when it is open or turned up, the burnt air

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361 Effect of its construction. The effect of this construction is very obvious. The fuel, being in immediate contact with the back and sides of the grate, heats them to a great degree, and they heat the air contiguous to them. This heated air cannot get up the vent, because the passages above these spaces are shut up. It therefore comes out into the room; some of it goes into the real fire-place and is carried up the vent, and the rest rises to the ceiling and is diffused over the room.

It is surprising to a person who does not consider it with skill how powerfully this grate warms a room. Less than one-fourth of the fuel consumed in an ordinary fire-place is sufficient; and this with the same cheerful blazing hearth and salutary renewal of air. It even requires attention to keep the room cool enough. The heat communicated to those parts in contact with the fuel is needlessly great; and it will be a considerable improvement to line this part with very thick plates of cast iron, or with tiles made of fire-clay which will not crack with the heat. These, being very bad conductors, will make the heat, ultimately communicated to the air, very moderate. If, with all these precautions, the heat should be found too great, it may be brought under perfect management by opening passages into the vent from the lateral spaces. These may be valves or trap-doors moved by rods concealed behind the ornaments.

Thus we have a fire-place under the most complete regulation, where we can always have a cheerful fire without being for a quarter of an hour incommoded by the heat; and we can as quickly raise our fire, when too low, by hanging on a plate of iron on the front, which shall reach as low as the grate. This in five minutes will blow up the fire into a glow; and the plate may be sent out of the room, or set behind the stove-grate out of sight.

The propriety of inclosing the ash-pit is not so obvious; but if this be not done, the light ashes, not finding a ready passage up the chimney, will come out into the room along with the heated air.

We do not consider in this place the various extraneous circumstances which impede the current of air in our chimneys and produce smoky houses: these will be treated of, and the methods of removing or remedying them, under the article SMOKE. We consider at present only the theory of this motion in general, and the modifications of its operation arising from the various purposes to which it may be applied.

362 Mode of warming apartments by stoves. Under this head we shall next give a general account and description of the method of warming apartments by stoves. A STOVE in general is a fire-place shut up on all sides, having only a passage for admitting the air to support the fire, and a tube for carrying off the vitiated air and smoke; and the air of the room is warmed by coming into contact with the outside of the stove and flue. The general principle of construction, therefore, is very simple. The air must be made to come into as close contact as possible with the fire, or even to pass through it, and this in such quantities as just to consume a quantity of fuel sufficient for producing the heat required; and the stove must be so constructed, that both the burning fuel and the air which has been heated by it shall be applied to as extensive a surface as possible of furnace, all in contact with the air of the room; and the heated air within the stove must not be allowed to get into the funnel which is to carry it off till it is too much cooled to produce any considerable heat on the outside of the stove.

In this temperate climate no great ingenuity is necessary for warming an ordinary apartment; and stoves are made rather to please the eye as furniture than as economical substitutes for an open fire of equal calorific power. But our neighbours on the continent, and especially towards the north, where the cold of winter is intense and fuel very dear, have bestowed much attention on their construction, and have combined ingenious economy with every elegance of form. Nothing can be handsomer than the stoves of Fayencerie that are to be seen in French Flanders, or the Russian stoves at St Petersburgh, finished in stucco. Our readers will not, therefore, be displeased with a description of them. In this place, however, we shall only consider a stove in general as a subject of pneumatical discussion, and we refer our readers to the article STOVE for an account of them as articles of domestic accommodation.

363 General form of a stove. The general form, therefore, of a stove, and of which all others are only modifications adapted to circumstances of utility or taste, is as follows:

Fig 79. MIKL (fig. 79.) is a quadrangular box of any size in the directions MILK. The inside width from front to back is pretty constant, never less than ten inches, and rarely extending to 20; the included space is divided by a great many partitions. The lowest chamber AB is the receptacle for the fuel, which lies on the bottom of the stove without any grate; this fire-place has a door AO turning on hinges, and in this door is a very small wicket P: the roof of the fire-place extends to within a very few inches of the farther end, leaving a narrow passage B for the flame. The next partition *c* C is about eight inches higher, and reaches almost to the other end, leaving a narrow passage for the flame at C. The partitions are repeated above, at the distance of eight inches, leaving passages at the ends, alternately disposed as in the figure; the last of them H communicates with the room vent. This communication may be regulated by a plate of iron, which can be slid across it by means of a rod or handle which comes through the side. The more usual way of shutting up this passage is by a sort of pan or bowl of earthen ware, which is whelmed over it with its brim resting in sand contained in a groove formed all round the hole. This damper is introduced by a door in the front, which is then shut. The whole is set on low pillars, so that its bottom may be a few inches from the floor of the room: it is usually placed in a corner, and the apartments are so disposed that their chimneys can be joined in stacks as with us.

Some straw or wood-shavings are first burnt on the hearth at its farther end. This warms the air in the stove, and creates a determined current. The fuel is then laid on the hearth close by the door, and pretty much piled up. It is now kindled; and the current being already directed to the vent, there is no danger of any smoke coming out into the room. Effectually to prevent this, the door is shut, and the wicket P opened.

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ed. The air supplied by this, being directed to the middle or bottom of the fuel, quickly kindles it, and the operation goes on.

364 Aim and effects of this construction.

The aim of this construction is very obvious. The flame and heated air are retained as long as possible within the body of the stove by means of the long passages; and the narrowness of these passages obliges the flame to come in contact with every particle of soot, so as to consume it completely, and thus convert the whole combustible matter of the fuel into heat. For want of this a very considerable portion of our fuel is wasted by our open fires, even under the very best management: the soot which sticks to our vents is very inflammable, and a pound weight of it will give as much if not more heat than a pound of coal. And what sticks to our vents is very inconsiderable in comparison with what escapes unconsumed at the chimney top. In fires of green wood, peat, and some kinds of pit-coal, nearly one-fifth of the fuel is lost in this way; but in these stoves there is hardly ever any mark of soot to be seen; and even this small quantity is produced only after lighting the fires. The volatile inflammable matters are expelled from parts much heated indeed, but not so hot as to burn; and some of it charred or half burnt cannot be any further consumed, being enveloped in flame and air already vitiated and unfit for combustion. But when the stove is well heated, and the current brisk, no part of the soot escapes the action of the air.

The hot air retained in this manner in the body of the stove is applied to its sides in a very extended surface. To increase this still more, the stove is made narrower from front to back in its upper part; a certain breadth is necessary below, that there may be room for fuel. If this breadth were preserved all the way up, much heat would be lost, because the heat communicated to the partitions of the stove does no good. By diminishing their breadth, the proportion of useful surface is increased. The whole body of the stove may be considered as a long pipe folded up, and its effect would be the greatest possible if it really were so; that is, if each partition *c* C, *d* D, &c. were split into two, and a free passage allowed between them for the air of the room. Something like this will be observed afterwards in some German stoves.

It is with the same view of making an extensive application of a hot surface to the air, that the stove is not built in the wall, not even in contact with it, nor with the floor: for by its detached situation, the air in contact with the back, and with the bottom (where it is hottest), is warmed, and contributes at least one half of the whole effect; for the great heat of the bottom makes its effect on the air of the room at least equal to that of the two ends. Sometimes a stove makes part of the wall between two small rooms, and is found sufficient.

It must be remarked, on the whole, that the effect of a stove depends much on keeping in the room the air already heated by it. This is so remarkably the case, that a small open fire in the same room will be so far from increasing its heat, that it will greatly diminish it: it will even draw the warm air from a suite of adjoining apartments. This is distinctly observed in the houses of the English merchants in St Petersburgh: their habits of life in Britain make them uneasy without an open fire in their sitting rooms; and this obliges them to heat all their stoves twice a-day, and their houses are cooler than those of the Russians who heat them only once. In many German houses, especially of the lower class, the fire-place of the stove does not open into the room, but into the yard or a lobby, where all the fires are lighted and tended; by this means is avoided the expence of warm air which must have been carried off by the stove: but it is evident, that this must be very unpleasant, and cannot be wholesome. We must breathe the same quantity of stagnant air loaded with all the vapours and exhalations which must be produced in every inhabited place. Going into one of these houses from the open air, is like putting one's head into a stew-pan or under a pie-crust, and quickly nauseates us who are accustomed to fresh air and cleanliness. In these countries it is a matter almost of necessity, to fumigate the rooms with frankincense and other gums burnt. The censer in ancient worship was in all probability an utensil introduced by necessity for sweetening or rendering tolerable the air of a crowded place: and it is a constant practice in the Russian houses for a servant to go round the room after dinner, waving a censer with some gums burning on bits of charcoal.

365 Of hot walls in gardening, &c.

The account now given of stoves for heating rooms, and of the circumstances which must be attended to in their construction, will equally apply to hot walls in gardening, whether within or without doors. The only new circumstance which this employment of a flue introduces, is the attention which must be paid to the equability of the heat, and the gradation which must be observed in different parts of the building. The heat in the flue gradually diminishes as it recedes from the fire-place, because it is continually giving out heat to the flue. It must therefore be so conducted through the building by frequent returns, that in every part there may be a mixture of warmer and cooler branches of the flue, and the final chimney should be close by the fire-place. It would, however, be improper to run the flue from the end of the floor up to the ceiling, where the second horizontal pipe would be placed, and then return it downward again and make the third horizontal flue adjoining to the first, &c. This would make the middle of the wall the coldest. If it is the flue of a greenhouse, this would be highly improper, because the upper part of the wall can be very little employed; and in this case it is better to allow the flue to proceed gradually up the wall in its different returns, by which the lowest part would be the warmest, and the heated air will ascend among the pots and plants; but in a hot wall, where the trees are to receive heat by contact, some approximation to the above method may be useful.

In the hypocausta and sudaria of the Greeks and Romans, the flue was conducted chiefly under the floors.

366 Malt kilns a species of stove.

Malt-kilns are a species of stove which merit our attention. Many attempts have been made to improve them on the principle of flue stoves; but they have been unsuccessful, because heat is not what is chiefly wanted in malting: it is a copious current of very dry air to carry off the moisture. We must refer the examination of this subject also to the article STOVE, and proceed to consider the current of heated air in the chief varieties of furnaces.

367 Of the current of air in melting furnaces.

All that is to be attended to in the different kinds of melting furnaces is, that the current of air be sufficiently rapid, and that it be applied in as extensive a surface as possible

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possible to the substance to be melted. The more rapid the current it is the hotter, because it is consuming more fuel; and therefore its effect increases in a higher proportion than its rapidity. It is doubly effectual if twice as hot; and if it then be twice as rapid, there is twice the quantity of doubly hot air applied to the subject; it would therefore be four times more powerful. This is procured by raising the chimney of the furnace to a greater height. The close application of it to the subject can hardly be laid down in general terms, because it depends on the precise circumstances of each case.

368 in reverberatory furnaces,

In reverberatory furnaces, such as refining furnaces for gold, silver, and copper, the flame is made to play over the surface of the melted metal. This is produced entirely by the form of the furnace, by making the arch of the furnace as low as the circumstances of the manipulation will allow. See FURNACE. Experience has pointed out in general the chief circumstances of their construction, viz. that the fuel should be at one end on a grate, through which the air enters to maintain the fire; and that the metal should be placed on a level floor between the fuel and the tall chimney which produces the current. But there is no kind of furnace more variable in its effect, and almost every place has a small peculiarity of construction, on which its pre-eminence is rested. This has occasioned many whimsical varieties in their form. This uncertainty seems to depend much on a circumstance rather foreign to our present purpose; but as we do not observe it taken notice of by mineralogical writers, we beg leave to mention it here. It is not heat alone that is wanted in the refining of silver by lead, for instance. We must make a continual application to its surface of air, which has not contributed to the combustion of the fuel. Any quantity of the hottest air, already saturated with the fuel, may play on the surface of the metal for ever, and keep it in the state of most perfect fusion, but without refining it in the least. Now, in the ordinary construction of a furnace, this is much the case. If the whole air has come in by the grate, and passed through the middle of the fuel, it can hardly be otherwise than nearly saturated with it; and if air be also admitted by the door (which is generally done or something equivalent), the pure air lies above the vitiated air, and during the passage along the horizontal part of the furnace, and along the surface of the metal, it still keeps above it, at least there is nothing to promote their mixture. Thus the metal does not come into contact with air fit to act on the base metal and calcine it, and the operation of refining goes on slowly. Trifling circumstances in the form of the arch or canal may tend to promote the jumbling of the airs together, and thus render the operation more expeditious; and as these are but ill understood, or perhaps this circumstance not attended to, no wonder that we see these considered as so many nostrums of great importance. It were therefore worth while to try the effect of changes in the form of the roof directed to this very circumstance. Perhaps some little prominence down from the arch of the reverberatory would have this effect, by suddenly throwing the current into confusion. If the additional length of passage do not cool the air too much, we should think that if there were interposed between the fuel and the refining floor a passage twisted like a cork-screw, making just half a turn, it would be most effectual: for we imagine, that the two airs, keeping each to their respective sides of the passage, would by this means be turned upside down, and that the pure stratum would now be in contact with the metal, and the vitiated air would be above it.

369 and in the glass-house furnaces.

The glasshouse furnace exhibits the chief variety in the management of the current of heated air. In this it is necessary that the hole at which the workman dips his pipe into the pot shall be as hot as any part of the furnace. This could never be the case, if the furnace had a chimney situated in a part above the dipping-hole; for in this case cold air would immediately rush in at the hole, play over the surface of the pot, and go up the chimney. To prevent this the hole itself is made the chimney; but as this would be too short, and would produce very little current and very little heat, the whole furnace is set under a tall dome. Thus the heated air from the real furnace is confined in this dome, and constitutes a high column of very light air, which will therefore rise with great force up the dome, and escape at the top. The dome is therefore the chimney, and will produce a draught or current proportioned to its height. Some are raised above a hundred feet. When all the doors of this house are shut, and thus no supply given except through the fire, the current and heat become prodigious. This, however, cannot be done, because the workmen are in this chimney, and must have respirable air. But notwithstanding this supply by the house-doors, the draught of the real furnace is vastly increased by the dome, and a heat produced sufficient for the work, and which could not have been produced without the dome.

370 Improvement of Mr Cotterel for melting iron from the ore.

This has been applied with great ingenuity and effect to a furnace for melting iron from the ore, and an iron finery, both without a blast. The common blast iron furnace is well known. It is a tall cone with the apex undermost. The ore and fluxes are thrown into this cone mixed intimately with the fuel till it is full, and the blast of most powerful bellows is directed into the bottom of this cone through a hole in the side. The air is thrown in with such force, that it makes its way through the mass of matter, kindles the fuel in its passage, and fluxes the materials, which then drop down into a receptacle below the blast-hole, and thus the passage for the air is kept unobstructed. It was thought impossible to produce or maintain this current without bellows; but Mr Cotterel, an ingenious founder, tried the effect of a tall dome placed over the mouth of the furnace, and though it was not half the height of many glasshouse domes it had the desired effect. Considerable difficulties, however, occurred; and he had not surmounted them all when he left the neighbourhood of Edinburgh, nor have we since heard that he has brought the invention to perfection. It is extremely difficult to place the holes below, at which the air is to enter, at such a precise height as neither to be choked by the melted matter, nor to leave ore and stones below them unmelted; but the invention is very ingenious, and will be of immense service if it can be perfected; for in many places iron ore is to be found where water cannot be had for working a blast furnace.

The last application which we shall make of the currents

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rents produced by heating the air is to the freeing mines, ſhips, priſons, &c. from the damp and noxious vapours which frequently infeſt them.

371 Currents of air applied to free mines, ſhips, priſons, &c. of noxious air.

As a drift or work is carried on in the mine, let a trunk of deal boards, about 6 or 8 inches ſquare, be laid along the bottom of the drift, communicating with a trunk carried up in the corner of one of the ſhafts. Let the top of this laſt trunk open into the aſh-pit of a ſmall furnace, having a tall chimney. Let fire be kindled in the furnace; and when it is well heated, ſhut the fire-place and aſh-pit doors. There being no other ſupply for the current produced in the chimney of this furnace, the air will flow into it from the trunk, and will bring along with it all the offenſive vapours. This is the moſt effectual method yet found out. In the ſame manner may trunks be conducted into the aſh-pit of a furnace from the cells of a priſon or the wards of an hoſpital.

372 Air neceſſary for the combuſtion of fuel.

In the account which we have been giving of the management of air in furnaces and common fires, we have frequently mentioned the immediate application of air to the burning fuel as neceſſary for its combuſtion. This is a general fact. In order that any inflammable body may be really inflamed, and its combuſtible matter conſumed and aſhes produced, it is not enough that the body be made hot. A piece of charcoal incloſed in a box of iron may be kept red hot for ever, without waſting its ſubſtance in the ſmalleſt degree. It is farther neceſſary that it be in contact with a particular ſpecies of air, which conſtitutes about three-fourths of the air of the atmoſphere, viz. the vital air or oxygen of Lavoiſier. It was called *empyreal air* by Scheele, who firſt obſerved its indiſpenſable uſe in maintaining fire: and it appears, that, in contributing to the combuſtion of an inflammable body, this air combines with ſome of its ingredients, and becomes fixed air, ſuffering the ſame change as by the breathing of animals. Combuſtion may therefore be conſidered as a ſolution of the inflammable body in air. This doctrine was firſt promulgated by the celebrated Dr Hooke in his *Micrographia*, publiſhed in 1660, and afterwards improved in his treatiſe on Lamps. It is now completely eſtabliſhed, and conſidered as a new diſcovery. It is for this reaſon, that in fire-places of all kinds we have directed the conſtruction, ſo as to produce a cloſe application of the air to the fuel. It is quite needleſs at this day to enter into the diſcuſſions which formerly occupied philoſophers about the manner in which the preſſure and elaſticity of the air promoted combuſtion. Many experiments were made in the 17th century by the firſt members of the Royal Society, to diſcover the office of air in combuſtion. It was thought that the flame was extinguiſhed in rare air for want of a preſſure to keep it together; but this did not explain its extinction when the air was not renewed. Theſe experiments are ſtill retained in courſes of experimental philoſophy, as they are judiciouſly ſtyled; but they give little or no information, nor tend to the illuſtration of any pneumatical doctrine; they are therefore omitted in this place. In ſhort, it is now fully eſtabliſhed, that it is not a mechanical but a chemical phenomenon. We can only inform the chemiſt, that a candle will conſume faſter in the low countries than in the elevated regions of Quito and Gondar, becauſe the air is nearly one half denſer below, and will act proportionally faſter in decompoſing the candle.

Pneumatic Engines.

373 Curious effect of the air's preſſure.

We ſhall conclude this part of our ſubject with the explanation of a curious phenomenon obſerved in many places. Certain ſprings or fountains are obſerved to have periods of repletion and ſcantineſs, or ſeem to ebb and flow at regular intervals; and ſome of theſe periods are of a complicated nature. Thus a well will have ſeveral returns of high and low water, the difference of which gradually increaſes to a maximum, and then diminiſhes, juſt as we obſerve in the ocean. A very ingenious and probable explanation of this has been given in N° 424. of the Philoſophical Tranſactions, by Mr Atwell, as follows.

Let ABCD (fig. 80.) repreſent a cavern, into which water is brought by the ſubterraneous paſſage OT. Let it have an outlet MNP, of a crooked form, with its higheſt part N conſiderably raiſed above the bottom of the cavern, and thence ſloping downwards into lower ground, and terminating in an open well at P. Let the dimenſions of this canal be ſuch that it will diſcharge much more water than is ſupplied by TO. All this is very natural, and may be very common. The effect of this arrangement will be a remitting ſpring at P: for when the cavern is filled higher than the point N, the canal MNP will act as a ſyphon; and, by the conditions aſſumed, it will diſcharge the water faſter than TO ſupplies it; it will therefore run it dry, and then the ſpring at P will ceaſe to furniſh water. After ſome time the cavern will again be filled up to the height N, and the flow at P will recommence. Fig. 80.

If, beſides this ſupply, the well P alſo receive water from a conſtant ſource, we ſhall have a reciprocating ſpring.

The ſituation and dimenſions of this ſyphon canal, and the ſupply of the feeder, may be ſuch, that the efflux at P will be conſtant. If the ſupply increaſe in a certain degree, a reciprocation will be produced at P with very ſhort intervals; if the ſupply diminiſhes conſiderably, we ſhall have another kind of reciprocation with great intervals and great differences of water.

If the cavern have another ſimple outlet R, new varieties will be produced in the ſpring P, and R will afford a copious ſpring. Let the mouth of R, by which the water enters into it from the cavern, be lower than N, and let the ſupply of the feeding ſpring be no greater than R can diſcharge, we ſhall have a conſtant ſpring from R, and P will give no water. But ſuppoſe that the main feeder increaſes in winter or in rainy ſeaſons, but not ſo much as will ſupply both P and R, the cavern will fill till the water gets over N, and R will be running all the while; but ſoon after P has begun to flow, and the water in the cavern ſinks below R, the ſtream from R will ſtop. The cavern will be emptied by the ſyphon canal MNP, and then P will ſtop. The cavern will then begin to fill, and when near full R will give a little water, and ſoon after P will run and R ſtop as before, &c.

Deſaguliers ſhows, vol. ii. p. 177, &c. in what manner a prodigious variety of periodical ebbs and flows may be produced by underground canals, which are extremely ſimple and probable.

374 Account of ſome pneumatic engines.

We ſhall conclude this article with the deſcriptions of ſome pneumatical machines or engines which have not been particularly noticed under their names in the former volumes of this work.

Bellows

Pneumatic Engines.

Bellows are of most extensive and important use; and it will be of service to describe such as are of uncommon construction and great power, fit for the great operations in metallurgy.

It is not the impulsive force of the blast that is wanted in most cases, but merely the copious supply of air, to produce the rapid combustion of inflammable matter; and the service would be better performed in general if this could be done with moderate velocities, and an extended surface. What are called air-furnaces, where a considerable surface of inflammable matter is acted on at once by the current which the mere heat of the expended air has produced, are found more operative in proportion to the air expended than blast furnaces animated by bellows; and we doubt not but that the method proposed by Mr Cotterel (which we have already mentioned) of increasing this current in a melting furnace by means of a dome, will in time supersede the blast furnaces. There is indeed a great impulsive force required in some cases; as for blowing off the scoriæ from the surface of silver or copper in refining furnaces, or for keeping a clear passage for the air in the great iron furnace.

In general, however, we cannot procure this abundant supply of air any other way than by giving it a great velocity by means of a great pressure, so that the general construction of bellows is pretty much the same in all kinds. The air is admitted into a very large cavity, and then expelled from it through a small hole.

The furnaces at the mines having been greatly enlarged; it was necessary to enlarge the bellows also: and the leathern bellows becoming exceedingly expensive, wooden ones were substituted in Germany about the beginning of the 17th century, and from them became general through Europe. They consist of a wooden box ABCPFE (fig. 92.), which has its top and two sides flat or straight, and the end BAE*e* formed into an arched or cylindrical surface, of which the line FP at the other end is the axis. This box is open below, and receives within it the shallow box KHGNML (fig. 93.), which exactly fills it. The line FP of the one coincides with FP of the other, and along this line is a set of hinges on which the upper box turns as it rises and sinks. The lower box is made fast to a frame fixed in the ground. A pipe OQ proceeds from the end of it, and terminates at the furnace, where it ends in a small pipe called the *tewer* or *tuyere*. This lower box is open above, and has in its bottom two large valves V, V, fig. 94. opening inwards. The conducting pipe is sometimes furnished with a valve opening outwards, to prevent burning coals from being sucked into the bellows when the upper box is drawn up. The joint along PF is made tight by thin leather nailed along it. The sides and ends of the fixed box are made to fit the sides and curved end of the upper box, so that this last can be raised and lowered round the joint FP without sensible friction, and yet without suffering much air to escape: but as this would not be sufficiently air-tight by reason of the shrinking and warping of the wood, a farther contrivance is adopted. A slender lath of wood, divided into several joints, and covered on the outer edge with very soft leather, is laid along the upper edges of the sides and ends of the lower box. This lath is so broad, that when its inner edge is even with the inside of the box, its outer edge projects about an inch. It is kept

Plate CCCCXXXII. Fig. 92.

Fig. 93.

Fig. 94.

in this position by a number of steel wires, which are driven into the bottom of the box, and stand up touching the sides, as represented in fig. 95. where *a b c* are the wires, and *e* the lath, projecting over the outside of the box. By this contrivance the laths are pressed close to the sides and curved end of the moveable box, and the spring wires yield to all their inequalities. A bar of wood RS (fig. 92.) is fixed to the upper board, by which it is either raised by machinery, to sink again by its own weight, having an additional load laid on it, or it is forced downward by a crank or wiper of the machinery, and afterwards raised.

Fig. 95.

Fig. 92.

The operation here is precisely similar to that of blowing with a chamber-bellows. When the board is lifted up, the air enters by the valves V, V, fig. 94. and is expelled at the pipe OQ by depressing the boards. There is therefore no occasion to insist on this point.

These bellows are made of a very great size, AD being 16 feet, AB five feet, and the circular end AE also five feet. The rise, however, is but about 3 or $3\frac{1}{2}$ feet. They expel at each stroke about 90 cubic feet of air, and they make about 8 strokes per minute.

Such are the bellows in general use on the continent. We have adopted a different form in this kingdom, which seems much preferable. We use an iron or wooden cylinder, with a piston sliding along it. This may be made with much greater accuracy than the wooden boxes, at less expence, if of wood, because it may be of coopers work, held together by hoops; but the great advantage of this form is its being more easily made air-tight. The piston is surrounded with a broad strap of thick and soft leather, and it has around its edge a deep groove, in which is lodged a quantity of wool. This is called the packing or stuffing, and keeps the leather very closely applied to the inner surface of the cylinder. Iron cylinders may be very neatly bored and smoothed, so that the piston, even when very tight, will slide along it very smoothly. To promote this, a quantity of black lead is ground very fine with water, and a little of this is smeared on the inside of the cylinder from time to time.

The cylinder has a large valve, or sometimes two, in the bottom, by which the atmospheric air enters when the piston is drawn up. When the piston is thrust down, this air is expelled along a pipe of great diameter, which terminates in the furnace with a small orifice.

This is the simplest form of bellows which can be conceived. It differs in nothing but size from the bellows used by the rudest nations. The Chinese smiths have a bellows very similar, being a square pipe of wood ABCDE (fig. 96.), with a square board G which exactly fits it, moved by the handle FG. At the farther end is the blast pipe HK, and on each side of it a valve in the end of the square pipe, opening inwards. The piston is sufficiently tight for their purposes without any leathering.

Fig. 96.

The piston of this cylinder bellows is moved by machinery. In some blast engines the piston is simply raised by the machine, and then let go, and it descends by its own weight, and compresses the air below it to such a degree, that the velocity of efflux becomes constant, and the piston descends uniformly: for this purpose it must be loaded with a proper weight. This produces a very uniform blast, except at the very beginning, while the piston falls suddenly and compresses the air: but in most engines the piston rod is forced down the

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the cylinder with a determined motion, by means of a beam, crank, or other contrivance. This gives a more unequal blaſt, becauſe the motion of the piſton is neceſſarily ſlow in the beginning and end of the ſtroke, and quicker in the middle.

But in all it is plain that the blaſt muſt be deſultory. It ceaſes while the piſton is riſing; for this reaſon it is uſual to have two cylinders, as it was formerly uſual to have two bellows which worked alternately. Sometimes three or four are uſed, as at the Carron iron works. This makes a blaſt abundantly uniform.

But an uniform blaſt may be made with a ſingle cylinder, by making it deliver its air into another cylinder, which has a piſton exactly fitted to its bore, and loaded with a ſufficient weight. The blowing cylinder ABCD (fig. 97.) has its piſton P worked by a rod NP, connected by double chains with the arched head of the working beam NO, moving round a gudgeon at R. The other end O of this beam is connected by the rod OP, with the crank PQ of a wheel machine; or it may be connected with the piſton of a ſteam engine, &c. &c. The blowing cylinder has a valve or valves E in its bottom, opening inwards. There proceeds from it a large pipe CF, which enters the regulating cylinder GHKI, and has a valve at top to prevent the air from getting back into the blowing cylinder. It is evident that the air forced into this cylinder muſt raiſe its piſton L, and that it muſt afterwards deſcend, while the other piſton is riſing. It muſt deſcend uniformly, and make a perfectly equable blaſt.

Fig. 97.

Obſerve, that if the piſton L be at the bottom when the machine begins to work, it will be at the bottom at the end of every ſtroke, if the *tuyere* T emits as much air as the cylinder ABCD furniſhes; nay, it will lie a while at the bottom, for, while it was riſing, air was iſſuing through T. This would make an interrupted blaſt. To prevent this, the orifice T muſt be leſſened; but then there will be a ſurplus of air at the end of each ſtroke, and the piſton L will riſe continually, and at laſt get to the top, and allow air to eſcape. It is juſt poſſible to adjuſt circumſtances, ſo that neither ſhall happen. This is done eaſier by putting a ſtop in the way of the piſton, and putting a valve on the piſton, or on the conducting pipe KST, loaded with a weight a little ſuperior to the intended elaſticity of the air in the cylinder. Therefore, when the piſton is prevented by the ſtop from riſing, the ſnifting valve, as it is called, is forced open, the ſuperfluous air eſcapes, and the blaſt preſerves its uniformity.

It may be of uſe to give the dimenſions of a machine of this kind, which has worked for ſome years at a very great furnace, and given ſatisfaction.

The diameter of the blowing cylinder is 5 feet, and the length of the ſtroke is 6. Its piſton is loaded with $3\frac{1}{2}$ tons. It is worked by a ſteam-engine whoſe cylinder is 3 feet 4 inches wide, with a ſix feet ſtroke. The regulating cylinder is 8 feet wide, and its piſton is loaded with $8\frac{1}{2}$ tons, making about 2.63 pounds on the ſquare inch; and it is very nearly in equilibrio with the load on the piſton of the blowing cylinder. The conducting pipe KST is 12 inches in diameter, and the orifice of the tuyere was $\frac{5}{8}$ of an inch when the engine was erected, but it has gradually enlarged by reaſon of the intenſe heat to which it is expoſed. The ſnifting valve is loaded with 3 pounds on the ſquare inch.

When the engine worked briſkly, it made 18 ſtrokes per minute, and there was always much air diſcharged by the ſnifting valve. When the engine made 15 ſtrokes per minute, the ſnifting valve opened but ſeldom, ſo that things were nearly adjuſted to this ſupply. Each ſtroke of the blowing cylinder ſent in 118 cubic feet of common air. The ordinary preſſure of the air being ſuppoſed $14\frac{3}{4}$ pounds on an inch, the denſity of the air in the regulating cylinder muſt be $\frac{14.75+2.63}{14.75}$, $=1.1783$, the natural denſity being 1.

This machine gives an opportunity of comparing the expence of air with the theory. It muſt (at the rate of 15 ſtrokes) expel 30 cubic feet of air in a ſecond through a hole of $1\frac{5}{8}$ inches in diameter. This gives a velocity of near 2000 feet per ſecond, and of more than 1600 feet for the condenſed air. This is vaſtly greater than the theory can give, or is indeed poſſible; for air does not ruſh into a void with ſo great velocity. It ſhows with great evidence, that a vaſt quantity of air muſt eſcape round the two piſtons. Their united circumferences amount to above 40 feet, and they move in a dry cylinder. It is impoſſible to prevent a very great loſs. Accordingly, a candle held near the edge of the piſton L has its flame very much diſturbed. This caſe, therefore, gives no hold for a calculation; and it ſuggeſts the propriety of attempting to diminiſh this great waſte.

This has been very ingeniouſly done (in part at leaſt) at ſome other furnaces. At Omoah foundery, near Glaſgow, the blowing cylinder (alſo worked by a ſteam engine) delivers its air into a cheſt without a bottom, which is immerſed in a large ciſtern of water, and ſupported at a ſmall height from the bottom of the ciſtern, and has a pipe from its top leading to the tuyere. The water ſtands about five feet above the lower brim of the regulating air-cheſt, and by its preſſure gives the moſt perfect uniformity of blaſt, without allowing a particle of air to get off by any other paſſage beſides the tuyere. This is a very effectual regulator, and muſt produce a great ſaving of power, becauſe a ſmaller blowing cylinder will thus ſupply the blaſt. We muſt obſerve, that the loſs round the piſton of the blowing cylinder remains undiminiſhed.

A blowing machine was erected many years ago at Chaſtillon in France on a principle conſiderably different, and which muſt be perfectly air-tight throughout. Two cylinders A, B (fig. 98.), loaded with great weights, were ſuſpended at the ends of the lever CD, moving round the gudgeon E. From the top F, G of each there was a large flexible pipe which united in H, from whence a pipe KT led to the tuyere T. There were valves at F and G opening outwards, or into the flexible pipes; and other valves L, M, adjoining to them in the top of each cylinder, opening inwards, but kept ſhut by a ſlight ſpring. Motion was given to the lever by a machine. The operation of this blowing machine is evident. When the cylinder A was pulled down, or allowed to deſcend, the water, entering at its bottom, compreſſed the air, and forced it along the paſſage FHKT. In the mean time, the cylinder B was riſing, and the air entered by the valve M. We ſee that the blaſt will be very unequal, increaſing as the cylinder is immerſed deeper. It is needleſs to deſcribe this machine more particularly, becauſe we ſhall give

Plate CCCCXXXIII. Fig. 98.

give an account of one which we think perfect in its kind, and which leaves hardly any thing to be desired in a machine of this sort. It was invented by Mr John Laurie, land-surveyor in Edinburgh, about 15 years ago, and improved in some respects since his death by an ingenious person of that city.

Fig. 99. ABCD (fig. 99.) is an iron cylinder, truly bored within, and evasated a-top like a cup. EFGH is another, truly turned both without and within, and a small matter less than the inner diameter of the first cylinder. This cylinder is close above, and hangs from the end of a lever moved by a machine. It is also loaded with weights at N. KILM is a third cylinder, whose outside diameter is somewhat less than the inside diameter of the second. This inner cylinder is fixed to the same bottom with the outer cylinder. The middle cylinder is loose, and can move up and down between the outer and inner cylinders without rubbing on either of them. The inner cylinder is perforated from top to bottom by three pipes OQ, SV, PR. The pipes OQ, PR have valves at their upper ends O, P, and communicate with the external air below. The pipe SV has a horizontal part VW, which again turns upwards, and has a valve at top X. This upright part WX is in the middle of a cistern of water *f h k g*. Into this cistern is fixed an air-chest *a* YZ *b*, open below, and having at top a pipe *c d e* terminating in the tuyere at the furnace.

When the machine is at rest, the valves X, O, P, are shut by their own weights, and the air-chest is full of water. When things are in this state, the middle cylinder EFGH is drawn up by the machinery till its lower brims F and G are equal with the top RM of the inner cylinder. Now pour in water or oil between the outer and middle cylinders: it will run down and fill the space between the outer and inner cylinders. Let it come to the top of the inner cylinder.

Now let the loaded middle cylinder descend. It cannot do this without compressing the air which is between its top and the top of the inner cylinder. This air being compressed will cause the water to descend between the inner and middle cylinders, and rise between the middle and outer cylinders, spreading into the cup; and as the middle cylinder advances downwards, the water will descend farther within it and rise farther without it. When it has got so far down, and the air has been so much compressed, that the difference between the surface of the water on the inside and outside of this cylinder is greater than the depth of water between X and the surface of the water *fg*, air will go out by the pipe SVW, and will lodge in the air-chest, and will remain there if *c* be shut, which we shall suppose for the present. Pushing down the middle cylinder till the partition touch the top of the inner cylinder, all the air which was formerly between them will be forced into the air-chest, and will drive out water from it. Draw up the middle cylinder, and the external air will open the valves O, P, and again fill the space between the middle and inner cylinders; for the valve X will shut, and prevent the regress of the condensed air. By pushing down the middle cylinder a second time, more air will be forced into the air-chest, and it will at last escape by getting out between its brims Y, Z and the bottom of the cistern; or if we open the passage *c*, it will pass along the conduit *c d e* to the tuyere, and form a blast.

The operation of this machine is similar to Mr Haskins's quicksilver pump described by Desaguliers at the end of the second volume of his Experimental Philosophy. The force which condenses the air is the load on the middle cylinder. The use of the water between the inner and outer cylinders is to prevent this air from escaping; and the inner cylinder thus performs the office of a piston, having no friction. It is necessary that the length of the outer and middle cylinders be greater than the depth of the regulator-cistern, that there may be a sufficient height for the water to rise between the middle and outer cylinders, to balance the compressed air, and oblige it to go into the air-chest. A large blast-furnace will require the regulator-cistern five feet deep, and the cylinders about six or seven feet long.

It is in fact a pump without friction, and is perfectly air-tight. The quickness of its operation depends on the small space between the middle cylinder and the two others; and this is the only use of these two. Without these it would be similar to the engine at Chastillon, and operate more unequally and slowly. Its only imperfection is, that if the cylinder begin its motion of ascent or descent rapidly, as it will do when worked by a steam-engine, there will be some danger of water dashing over the top of the inner cylinder and getting into the pipe SV; but should this happen, an issue can easily be contrived for it at V, covered with a loaded valve *v*. This will never happen if the cylinder is moved by a crank.

One blowing cylinder only is represented here, but two may be used.

We do not hesitate in recommending this form of bellows as the most perfect of any, and fit for all uses where standing bellows are required. They will be cheaper than any other sort for common purposes. For a common smith's forge they may be made with square wooden boxes instead of cylinders. They are also easily repaired. They are perfectly tight; and they may be made with a blast almost perfectly uniform, by making the cistern in which the air-chest stands of considerable dimensions. When this is the case, the height of water, which regulates the blast, will vary very little.

This may suffice for an account of blast machines. The leading parts of their construction have been described as far only as was necessary for understanding their operation, and enabling an engineer to erect them in the most commodious manner. Views of complete machines might have amused, but they would not have added to our reader's information.

But the account is imperfect unless we show how their parts may be so proportioned that they shall perform what is expected from them. The engineer should know what size of bellows, and what load on the board or piston, and what size of tuyere, will give the blast which the service requires, and what force must be employed to give them the necessary degree of motion. We shall accomplish these purposes by considering the efflux of the compressed air through the tuyere. The propositions formerly delivered will enable us to ascertain this.

That we may proportion every thing to the power employed,

employed, we muſt recollect, that if the piſton of a cylinder employed for expelling air be preſſed down with any force p, it muſt be conſidered as ſuperadded to the atmoſpheric preſſure P on the ſame piſton, in order that we may compare the velocity v of efflux with the known velocity V with which air ruſhes into a void. By what has been formerly delivered, it appears that this velocity $v = V \times \sqrt{\frac{p}{P \times p}}$, where P is the preſſure of the atmoſphere on the piſton, and p the additional load laid on it. This velocity is expreſſed in feet per ſecond; and, when multiplied by the area of the orifice (alſo expreſſed in ſquare feet), it will give us the cubical feet of condenſed air expelled in a ſecond: but the bellows are always to be filled again with common air, and therefore we want to know the quantity of common air which will be expelled; for it is this which determines the number of ſtrokes which muſt be made in a minute, in order that the proper ſupply may be obtained. Therefore recollect that the quantity expelled from a given orifice with a given velocity, is in the proportion of the denſity; and that when D is the denſity of common air produced by the preſſure P, the denſity d produced by the preſſure $P+p$, is $D \times \frac{P+p}{P}$; or if D be made 1, we have $d = \frac{P+p}{P}$.

Therefore, calling the area of the orifice expreſſed in ſquare feet O, and the quantity of common air, or the cubic feet expelled in a ſecond Q, we have $Q = V \times O \times \sqrt{\frac{p}{P+p}} \times \frac{P+p}{P}$.

It will be ſufficiently exact for all practical purpoſes to ſuppoſe P to be 15 pounds on every ſquare inch of the piſton; and p is then conveniently expreſſed by the pounds of additional load on every ſquare inch: we may alſo take $V = 1332$ feet.

As the orifice through which the air is expelled is generally very ſmall, never exceeding three inches in diameter, it will be more convenient to expreſs it in ſquare inches; which being the $\frac{1}{144}$ of a ſquare foot, we ſhall have the cubic feet of common air expelled in a ſecond, or $Q = \frac{1332}{144} O \sqrt{\frac{p}{P+p}} \times \frac{P+p}{P}, = O \times 9.25 \times \sqrt{\frac{p}{P+p}} \times \frac{P+p}{P}$; and this ſeems to be as ſimple an expreſſion as we can obtain.

This will perhaps be illuſtrated by taking an example in numbers. Let the area of the piſton be four ſquare feet, and the area of the round hole through which the air is expelled be two inches, its diameter being 1.6, and let the load on the piſton be 1728 pounds: this is three pounds on every ſquare inch. We have $P=15$, $p=3$, $P+p=18$, and $O=2$; therefore we will have $Q = 2 \times 9.25 \times \sqrt{\frac{3}{18}} \times \frac{18}{15}, = 9.053$ cubic feet of common air expelled in a ſecond. This will however be diminiſhed at leaſt one-third by the contraction of the jet; and therefore the ſupply will not exceed ſix cubic feet per ſecond. Suppoſing therefore that this blowing machine is a cylinder or priſm of this dimenſion in its ſection, the piſton ſo loaded would (after having compreſſed the air) deſcend about 15 inches in a ſecond: It would firſt ſink one-fifth of the whole length of the cylinder pretty ſuddenly, till it had reduced the air to the denſity $\frac{18}{15}$, and would then deſcend uniformly at the above rate, expelling ſix cubic feet of common air in a ſecond.

The computation is made much in the ſame way for bellows of the common form, with this additional circumſtance, that as the loaded board moves round a hinge at one end, the preſſure of the load muſt be calculated accordingly. The computation, however, becomes a little intricate, when the form of the loaded board is not rectangular: it is almoſt uſeleſs when the bellows have flexible ſides, either like ſmiths bellows or like organ bellows, becauſe the change of figure during their motion makes continual variation on the compreſſing powers. It is therefore chiefly with reſpect to the great wooden bellows, of which the upper board ſlides down between the ſides, that the above calculation is of ſervice.

The propriety, however, of this piece of information is evident: we do not know preciſely the quantity of air neceſſary for animating a furnace; but this calculation tells us what force muſt be employed for expelling the air that may be thought neceſſary. If we have fixed on the ſtrength of the blaſt, and the diameter of the cylinder, we learn the weight with which the piſton muſt be loaded; the length of the cylinder determines its capacity, the above calculation tells the expence per ſecond; hence we have the time of the piſton's coming to the bottom. This gives us the number of ſtrokes per minute: the load muſt be lifted up by the machine this number of times, making the time of aſcent preciſely equal to that of deſcent; otherwiſe the machine will either catch and ſtop the deſcent of the piſton, or allow it to lie inactive for a while of each ſtroke. Theſe circumſtances determine the labour to be performed by the machine, and it muſt be conſtructed accordingly. Thus the engineer will not be affronted by its failure, nor will he expend needleſs power and coſt.

In machines which force the piſton or bellows-board with a certain determined motion, different from what ariſes from their own weight, the computation is extremely intricate. When a piſton moves by a crank, its motion at the beginning and end of each ſtroke is ſlow, and the compreſſion and efflux is continually changing: we can however approximate to a ſtatement of the force required.

Every time the piſton is drawn up, a certain ſpace of the cylinder is filled again with air of the common denſity; and this is expelled during the deſcent of the piſton. A certain number of cubic feet of common air is therefore expelled with a velocity which perhaps continually varies; but there is a medium velocity with which it might have been uniformly expelled, and a preſſure correſponding to this velocity. To find this, divide the area of the piſton by the area of the blaſt-hole (or rather by this area multiplied by 0.613, in order to take in the effect of the contracted jet), and multiply the length of the ſtroke performed in a ſecond by the quotient ariſing from this diviſion; the product is the medium velocity of the air (of the natural denſity). Then find by calculation the height through which a heavy body muſt fall in order to acquire this velocity; this is the height of a column of homogeneous air which would expel

expel it with this velocity. The weight of this column is the leaft force that can be exerted by the engine: but this force is too fmall to overcome the refiftance in the middle of the ftroke, and it is too great even for the end of the ftroke, and much too great for the beginning of it. But if the machine is turned by a very heavy water-wheel, this will act as a regulator, accumulating in itfelf the fuperfluous force during the too favourable pofitions of the crank, and exerting it by its *vis infita* during the time of greateft effort. A force not greatly exceeding the weight of this column of air will therefore fuffice. On the other hand, if the ftrength of the blaft be determined, which is the general ftate of the problem, this determines the degree of condenfation of the air, and the load on the fquare inch of the pifton, or the mean force which the machine muft exert on it. A table, which will be given prefently, determines the cubic feet of common air expelled in a fecond, correfponding to this load. This combined with the propofed dimenfions of the cylinder, will give the defcent of the pifton or the length of the ftroke.

Thefe general obfervations apply to all forms of bellows; and without a knowledge of them no perfon can erect a machine for working them without total uncertainty or fervile imitation. In order, therefore, that they may be ufeful to fuch as are not accuftomed to the management of even thefe fimple formulæ, we infert the following fhort table of the velocity and quantity of air difcharged from a cylinder whofe pifton is loaded with the pounds contained in the firft column on every fquare inch. The fecond column contains the velocity with which the *condenfed air* rufhes out through any *fmall* hole; and the third column is the cubic feet difcharged from a hole whofe area is a fquare inch; column fourth contains the mean velocity of air of the common denfity; and column fifth is the cubic feet of common air difcharged; the fixth column is the height in inches at which the force of the blaft would fupport a column of water if a pipe were inferted into the fide of the cylinder. This is an extremely proper addition to fuch machines, fhowing at all times the power of the machines, and teaching us what intenfity of blaft is employed for different purpofes. The table is computed from the fuppofition that the ordinary preffure of the air is 15 pounds on a fquare inch. This is fomewhat too great, and therefore the velocities are a little too fmall; but the quantities difcharged will be found about one-third too great (without affecting the velocities) on account of the convergency of the ftream.

I	II	III	IV	V	VI
½	239	1.66	247	1.72	14
1	333	2.32	355	2.47	27
1½	404	2.79	437	3.05	40
2	457	3.17	518	3.60	54
2½	500	3.48	584	4.2	68
3	544	3.76	653	4.53	82
3½	582	4.03	715	4.98	95
4	611	4.24	774	5.38	109
4½	642	4.46	822	5.75	122
5	666	4.67	888	6.17	136
5½	693	4.84	950	6.49	150
6	711	5.06	997	6.92	163

This table extends far beyond the limits of ordinary ufe, very few blaft-furnaces having a force exceeding 60 inches of water.

We fhall conclude this account of blowing machines with a defcription of a fmall one for a blowpipe. ABCD, fig. 100. is a veffel containing water, about two feet deep. EFGH is the air-box of the blower, open below, and having a pipe ILK rifing up from it to a convenient height; an arm ON which grafps this pipe carries the lamp N: the blowpipe LM comes from the top of the upright pipe. PKQ is the feeding pipe, reaching near to the bottom of the veffel. Fig. 100.

Water being poured into the veffel below, and its cover being put on, which fits the upright pipe, and touches two ftuds *a*, *a*, projecting from it, blow in a quantity of air by the feeding pipe PQ; this expels the water from the air-box, and occafions a preffure which produces the blaft through the blowpipe M.

In N° 54. of this article, we mentioned an application which has been made of Hero's fountain, at Chemnitz in Hungary, for raifing water from the bottom of a mine. We fhall now give an account of this very ingenious contrivance.

In fig. 101. B reprefents the fource of water elevated above the mouth of the pit 136 feet. From this there is led a pipe B*b*CD four inches diameter. This pipe enters the top of a copper cylinder *b c d e*, 8½ feet high, five feet diameter, and two inches thick, and it reaches to within four inches of the bottom; it has a cock at C. This cylinder has a cock at F, and a very large one at E. From the top *b c* proceeds a pipe GHH′ two inches in diameter, which goes down the pit 96 feet, and is inferted into the top of another brafs cylinder *f g h i*, which is 6½ feet high, four feet diameter, and two inches thick, containing 83 cubic feet, which is very nearly one half of the capacity of the other, viz. of 170 cubic feet. There is another pipe NI of four inches diameter, which rifes from within four inches of the bottom of this lower cylinder, is foldered into its top, and rifes to the trough NO, which carries off the water from the mouth of the pit. This lower cylinder communicates at the bottom with the water L which collects in the drains of the mine. A large cock K ferves to admit or exclude this water; another cock M, at the top of this cylinder, communicates with the external air. Fig. 101.

Now fuppofe the cock C fhut, and all the reft open; the upper cylinder will contain air, and the lower cylinder will be filled with water, becaufe it is funk fo deep that its top is below the ufual furface of the mine-waters. Now fhut the cocks F, E, M, K, and open the cock C. The water of the fource B muft run in by the orifice D, and rife in the upper cylinder, compreffing the air above it and along the pipe GHH′, and thus acting on the furface of the water in the lower cylinder. It will therefore caufe it to rife gradually in the pipe IN, where it will always be of fuch a height that its weight balances the elafticity of the compreffed air. Suppofe no iffue given to the air from the upper cylinder, it would be compreffed into one-fifth of its bulk by the column of 136 feet high; for a column of 34 feet nearly balances the ordinary elafticity of the air. Therefore, when there is an iffue given to it through the pipe GHH′, it will drive the compreffed air along this pipe, and it will expel water from the lower cylinder.

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der. When the upper cylinder is full of water, there will be 34 cubic feet of water expelled from the lower cylinder. If the pipe IN had been more than 136 feet long, the water would have risen 136 feet, being then in equilibrio with the water in the feeding pipe B*b*CD (as was shown in N° 52.), by the intervention of the elastic air; but no more water would have been expelled from the lower cylinder than what fills this pipe. But the pipe being only 96 feet high, the water will be thrown out at N with a very great velocity. If it were not for the great obstructions which water and air must meet with in their passage along pipes, it would issue at N with a velocity of more than 50 feet per second. It issues much more slowly, and at last the upper cylinder is full of water, and the water would enter the pipe GH and enter the lower cylinder, and without displacing the air in it, would rise through the discharging pipe IN, and run off to waste. To prevent this there hangs in the pipe HG a cork ball or double cone, by a brass wire which is guided by holes in two cross pieces in the pipe HG. When the upper cylinder is filled with water, this cork plugs up the orifice G, and no water is wasted; the influx at D now stops. But the lower cylinder contains compressed air, which would balance water in a discharging pipe 136 feet high, whereas IN is only 96. Therefore the water will continue to flow at N till the air has so far expanded as to balance only 96 feet of water, that is, till it occupies one fourth of its ordinary bulk, that is, one-fourth of the capacity of the upper cylinder, or 42½ cubic feet. Therefore 42½ cubic feet will be expelled, and the efflux at N will cease; and the lower cylinder is about one half full of water. When the attending workman observes this, he shuts the cock C. He might have done this before, had he known when the orifice G was stopped; but no loss ensues from the delay. At the same time the attendant opens the cock E, the water issues with great violence, being pressed by the condensed air from the lower cylinder. It therefore issues with the sum of its own weight and of this compression. These gradually decrease together, by the efflux of the water and the expansion of the air; but this efflux stops before all the water has flowed out; for there is 42½ feet of the lower cylinder occupied by air. This quantity of water remains, therefore, in the upper cylinder nearly: the workman knows this, because the discharged water is received first of all into a vessel containing three-fourths of the capacity of the upper cylinder. Whenever this is filled, the attendant opens the cock K by a long rod which goes down the shaft; this allows the water of the mine to fill the lower cylinder, allows the air to get into the upper cylinder, and this allows the remaining water to run out of it.

And thus every thing is brought into its first condition; and when the attendant sees no more water come out at E, he shuts the cocks E and M, and opens the cock C, and the operation is repeated.

There is a very surprising appearance in the working of this engine. When the efflux at N has stopped, if the cock F be opened, the water and air rush out together with prodigious violence, and the drops of water are changed into hail or lumps of ice. It is a sight usually shown to strangers, who are desired to hold their hats to receive the blast of air: the ice comes out with such violence as frequently to pierce the hat like a pistol bullet. This rapid congelation is a remarkable instance of the general fact, that air by suddenly expanding, generates cold, its capacity for heat being increased. Thus the peasant cools his broth by blowing over the spoon, even from warm lungs: a stream of air from a pipe is always cooling.

The above account of the procedure in working this engine shows that the efflux both at N and E becomes very slow near the end. It is found convenient therefore not to wait for the complete discharges, but to turn the cocks when about 30 cubic feet of water have been discharged at N: more work is done in this way. A gentleman of great accuracy and knowledge of these subjects took the trouble, at our desire, of noticing particularly the performance of the machine. He observed that each stroke, as it may be called, took up about three minutes and one-eighth; and that 32 cubic feet of water were discharged at N, and 66 were expended at E. The expence therefore is 66 feet of water falling 136 feet, and the performance is 32 raised 96, and they are in the proportion of 66×136 to 32×96, or of 1 to 0.3422, or nearly as 3 to 1. This is superior to the performance of the most perfect undershot mill, even when all friction and irregular obstructions are neglected; and is not much inferior to any overshot pump-mill that has yet been erected. When we reflect on the great obstructions which water meets with in its passage through long pipes, we may be assured that, by doubling the size of the feeder and discharger, the performance of the machine will be greatly improved; we do not hesitate to say, that it would be increased one-third: it is true that it will expend more water; but this will not be nearly in the same proportion; for most of the deficiency of the machine arises from the needless velocity of the first efflux at N. The discharging pipe ought to be 110 feet high, and not give sensibly less water.

Then it must be considered how inferior in original expence this simple machine must be to a mill of any kind which would raise 10 cubic feet 96 feet high in a minute, and how small the repairs on it need be, when compared with a mill.

And, lastly, let it be noticed, that such a machine can be used where no mill whatever can be put in motion. A small stream of water, which would not move any kind of wheel, will here raise one-third of its own quantity to the same height; working as fast as it is supplied.

For all these reasons, we think that the Hungarian machine eminently deserves the attention of mathematicians and engineers, to bring it to its utmost perfection, and into general use. There are situations where this kind of machine may be very useful. Thus, where the tide rises 17 feet, it may be used for compressing air to seven-eighths of its bulk; and a pipe leading from a very large vessel inverted in it, may be used for raising the water from a vessel of one-eighth of its capacity 17 feet high; or if this vessel has only $\frac{1}{16}$ of the capacity of the large one set in the tide way, two pipes may be led from it, one into the small vessel and the other into an equal vessel 16 feet higher, which receives the water from the first. Thus one-sixteenth of the water may be raised 34 feet, and a smaller quantity to a still greater height; and this with a kind of power that can hardly be applied in any other way. Machines of this kind are described by Schottus, Sturmius, Leupold, and other old writers; and they should not be forgotten, because opportunities may

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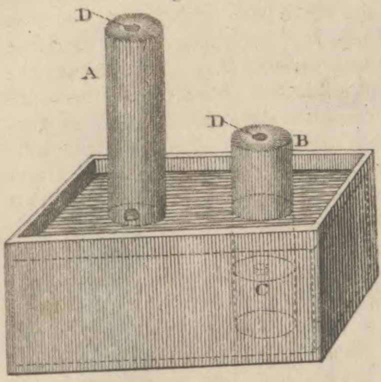

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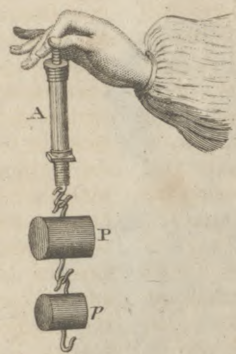

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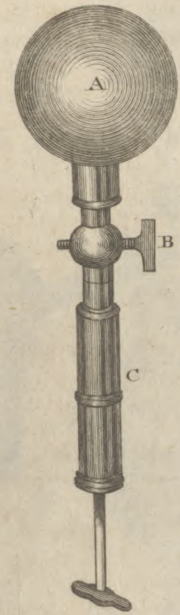

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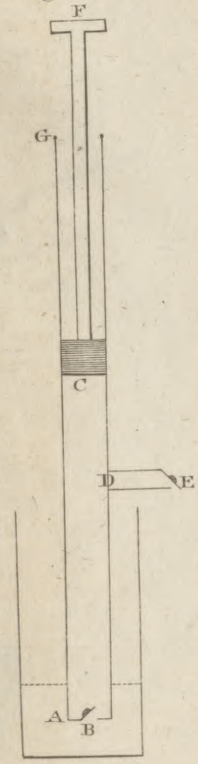

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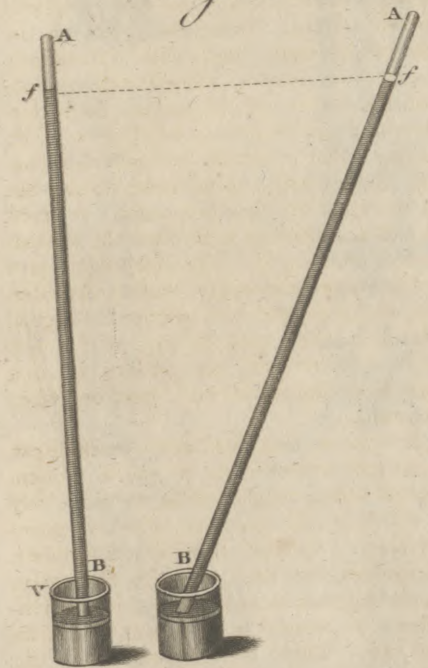

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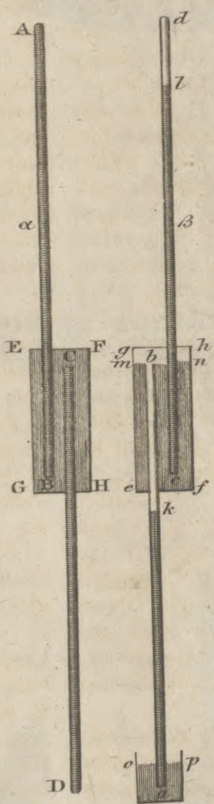

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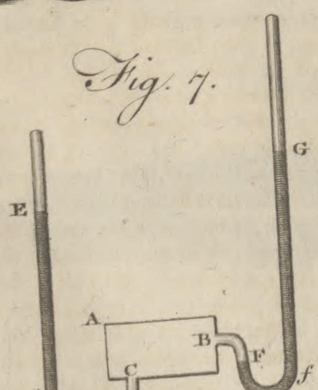

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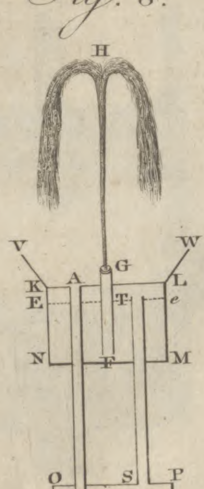

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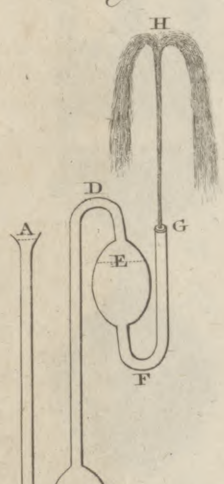

A. Bell Prin. Wal. Sculptor fecit.

PNEUMATICS.

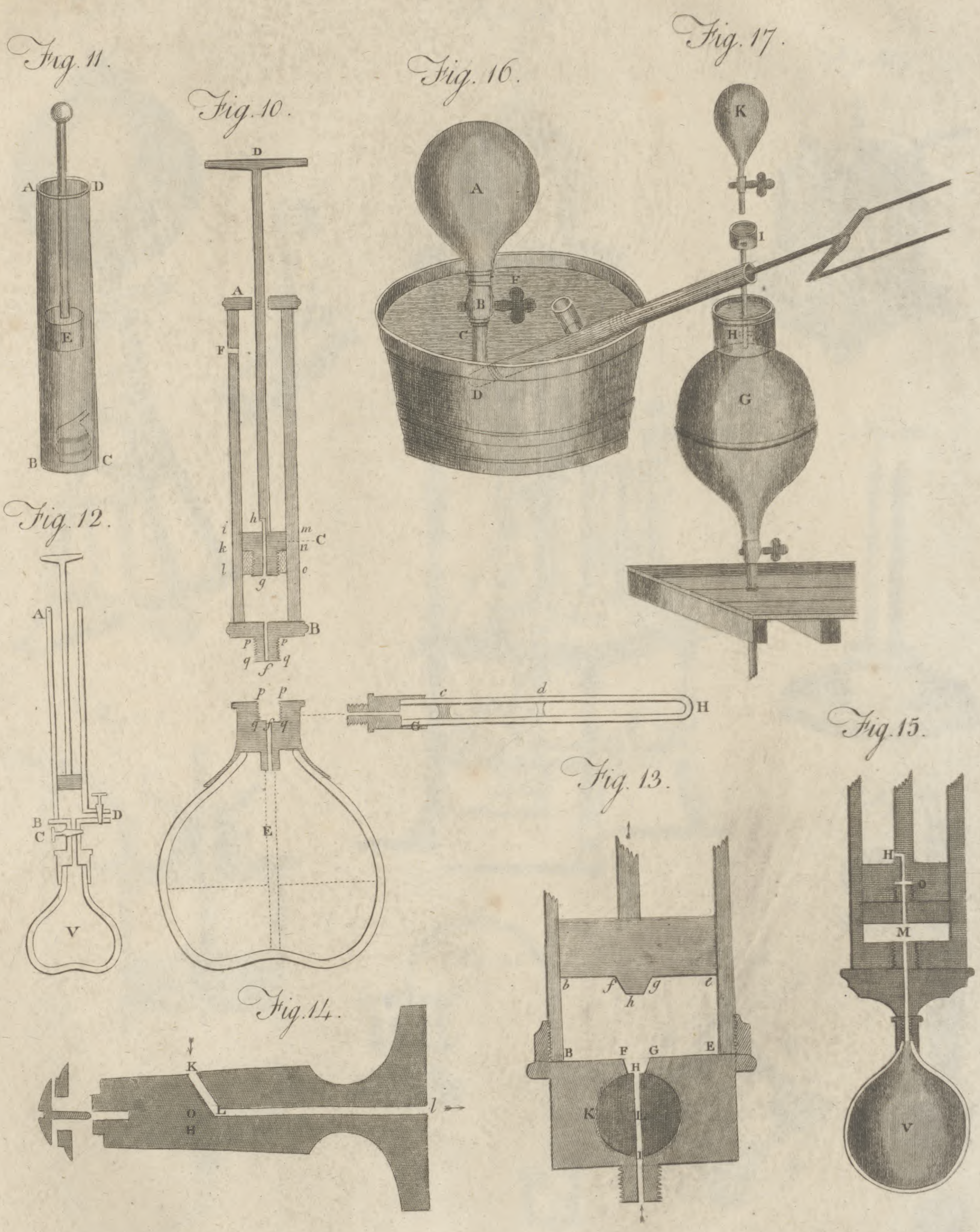

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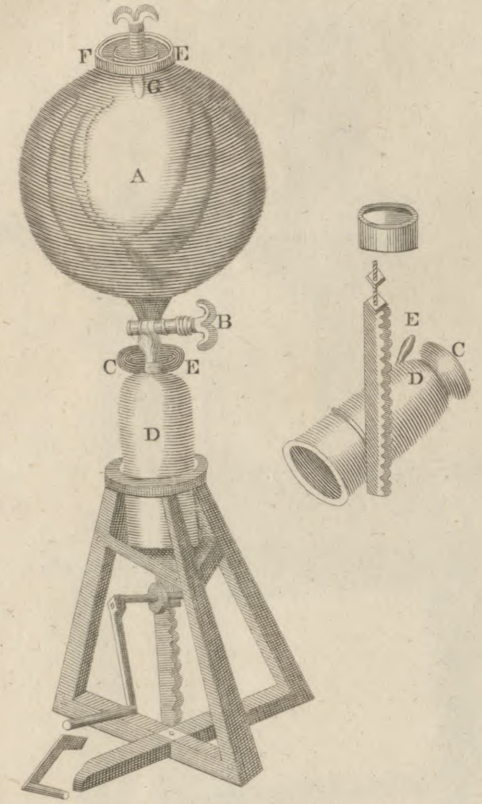
Fig. 18.



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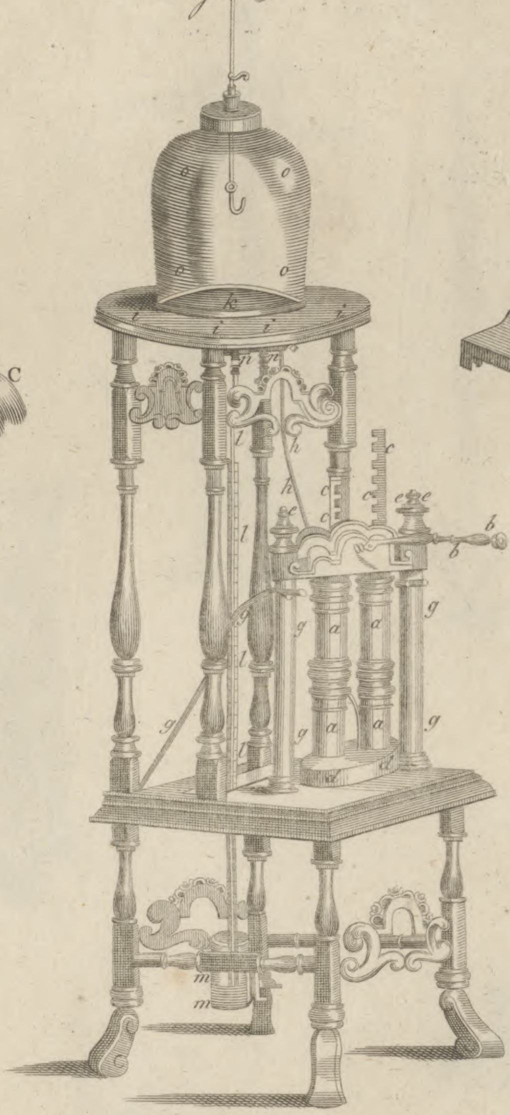

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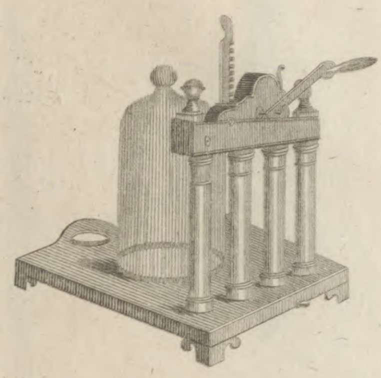

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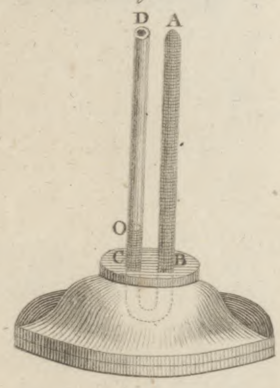

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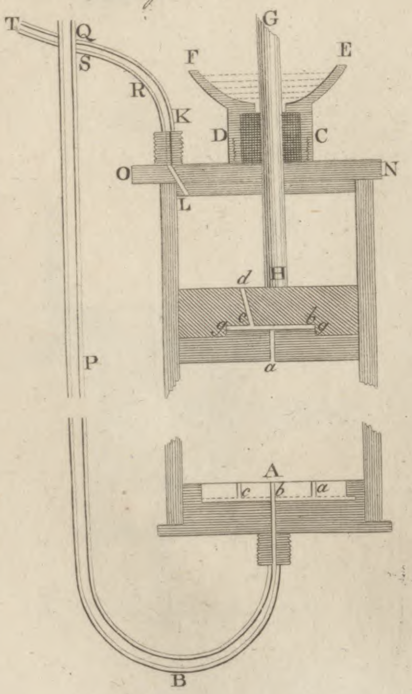

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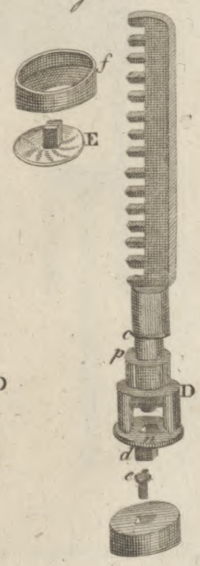

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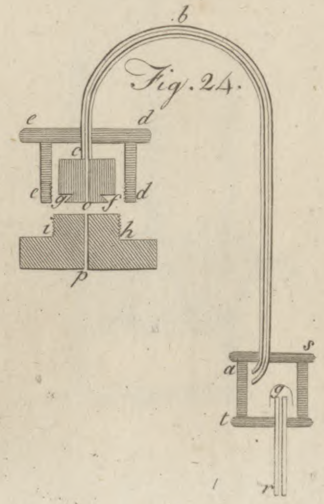

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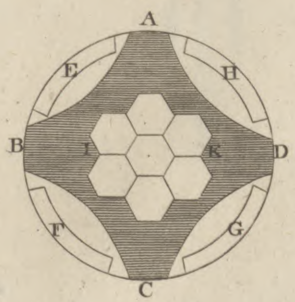
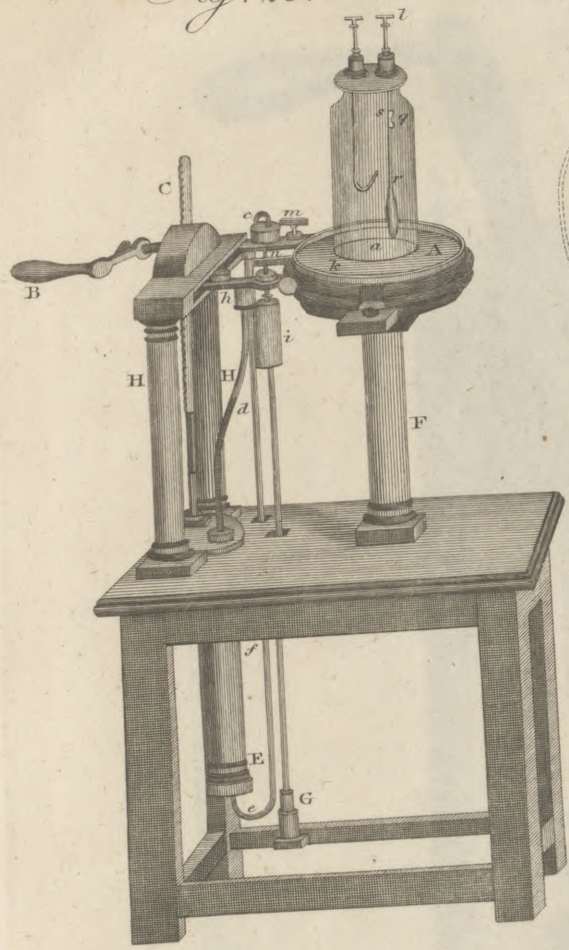


A.Bell Prin. Wal. Sculptor fecit.

Fig. 26.



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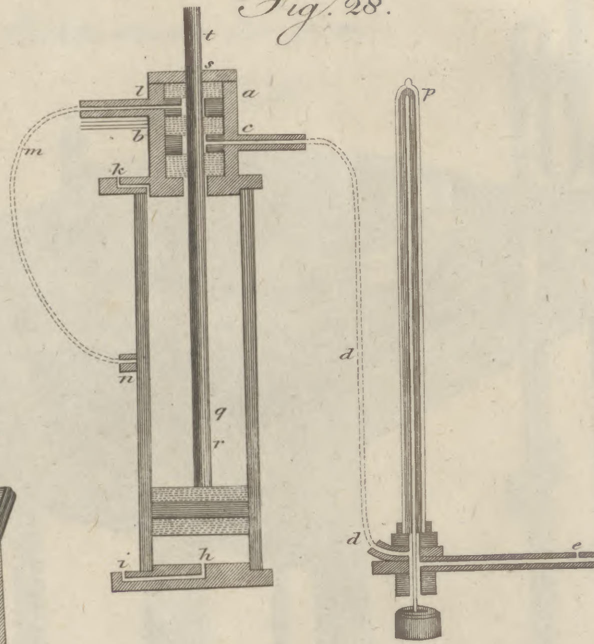
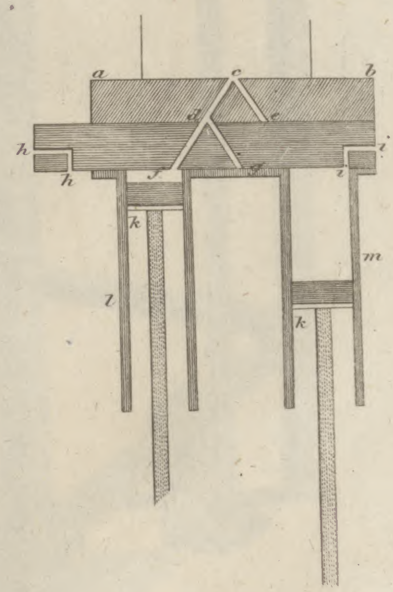


Fig. 27.

Fig. 31.



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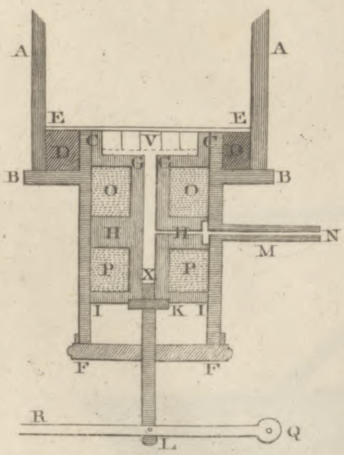

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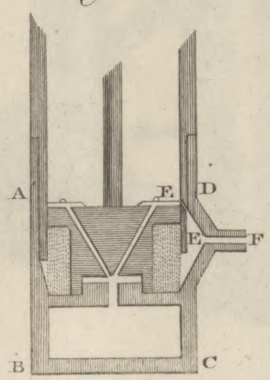
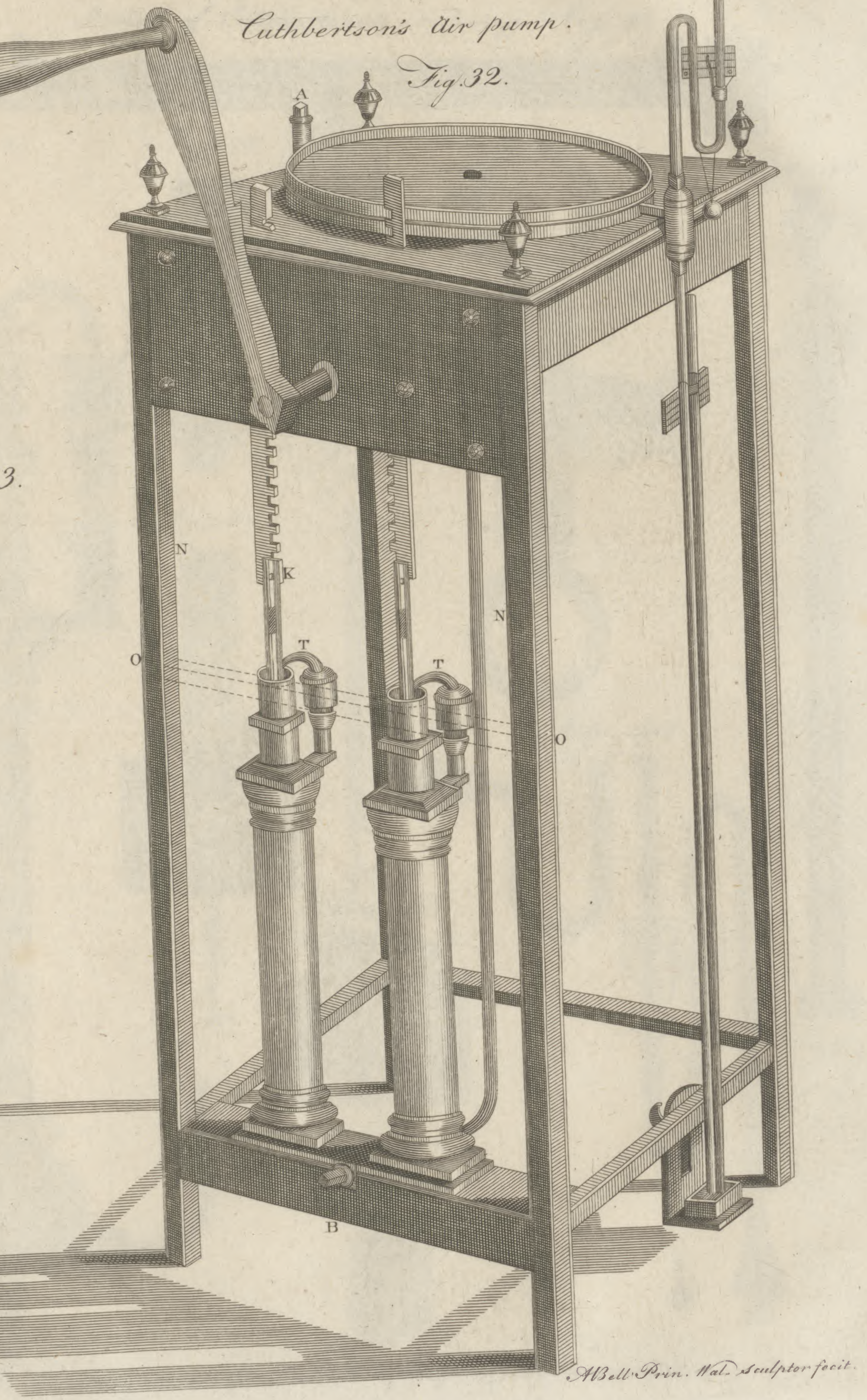


A. Bell Prin. Wal. Sculptor fecit.

Cuthbertson's air pump.

Fig. 32.



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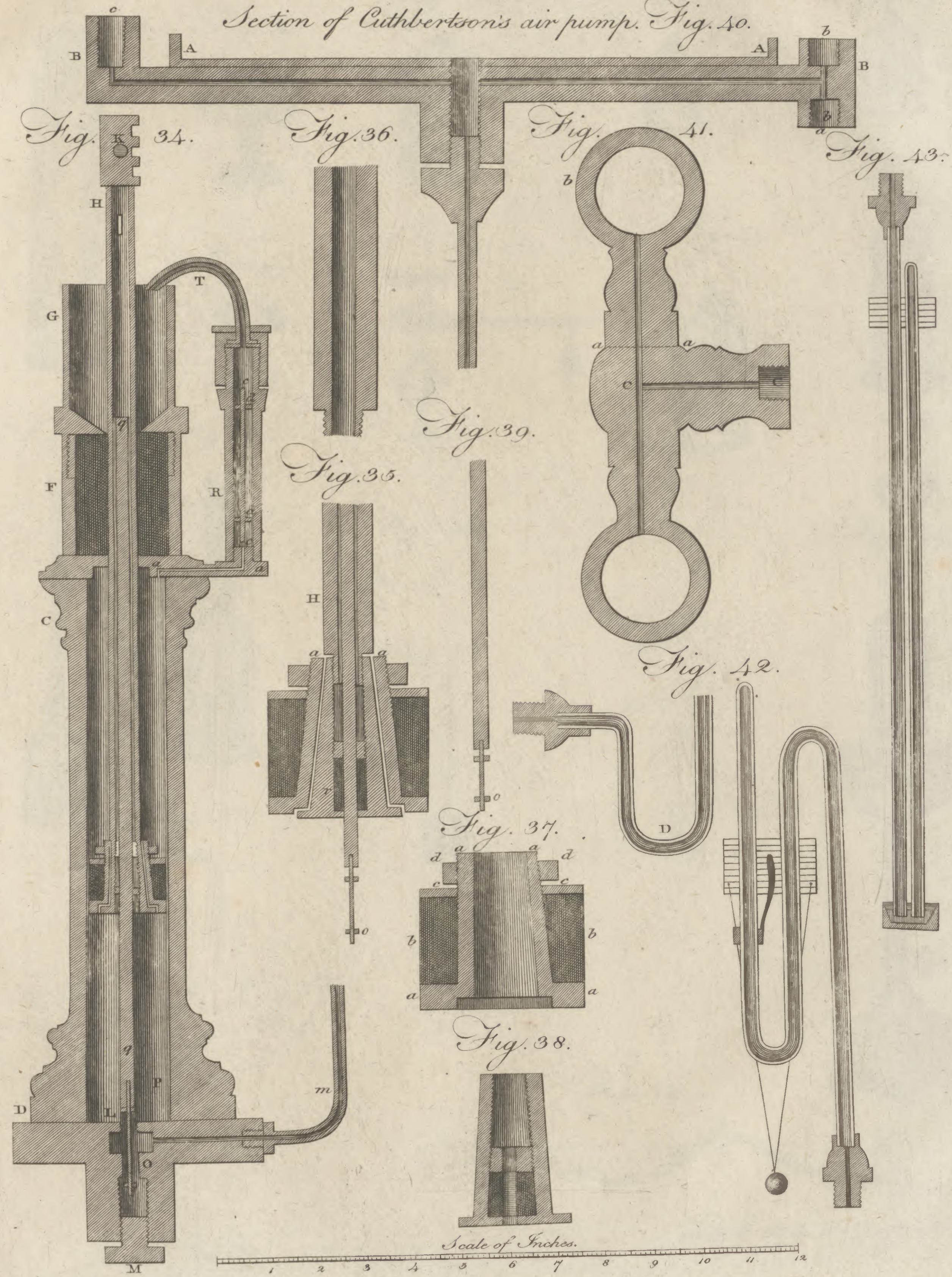

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PNEUMATICS. Plate CCCCXXIX.

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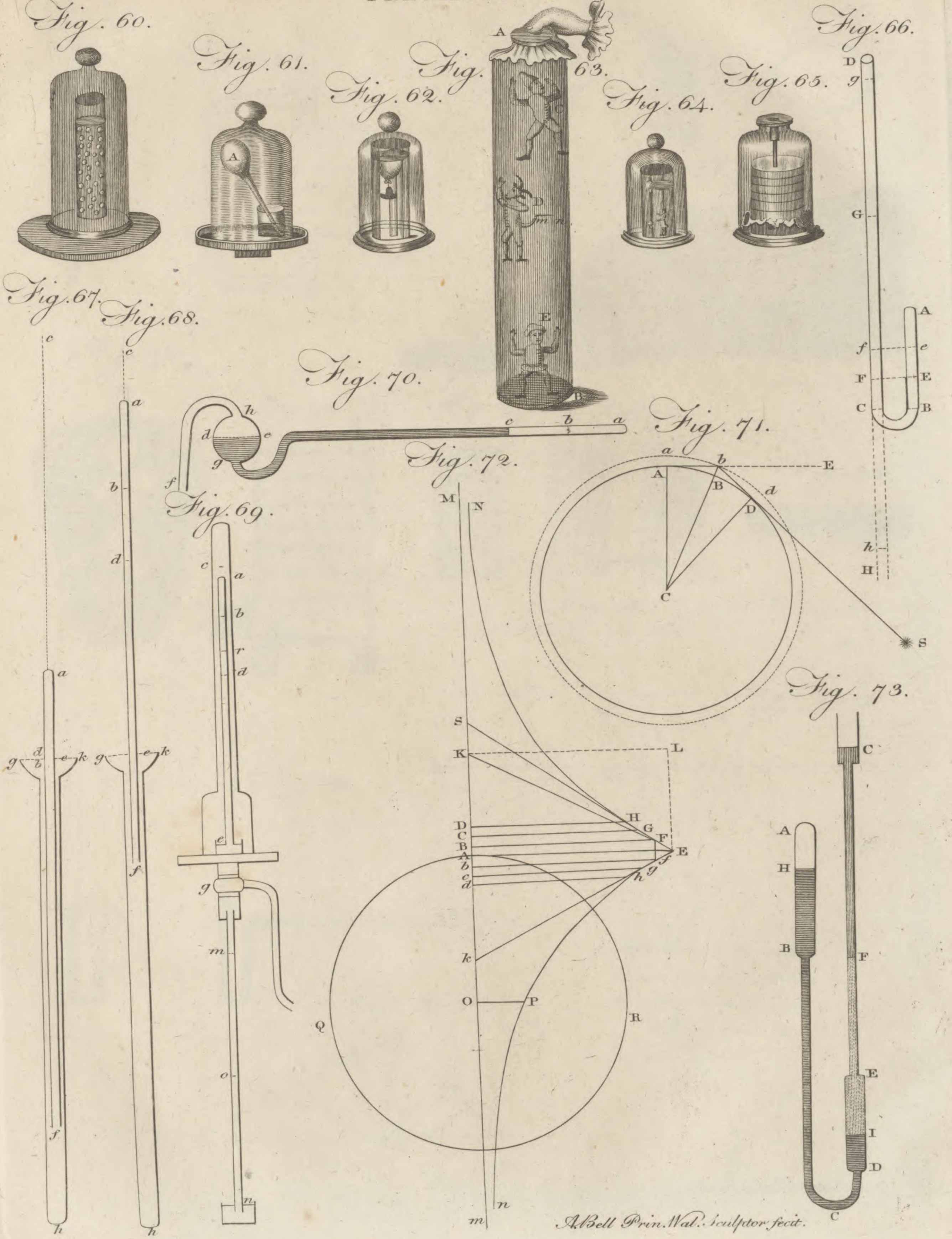

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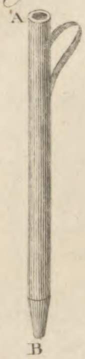
Fig. 74.



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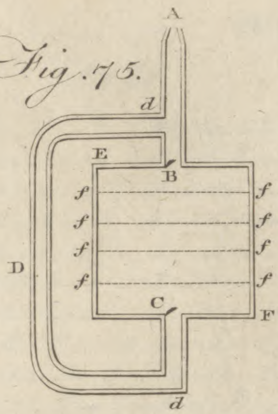

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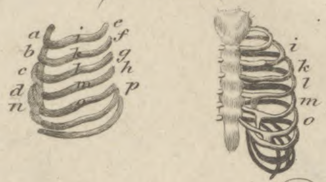
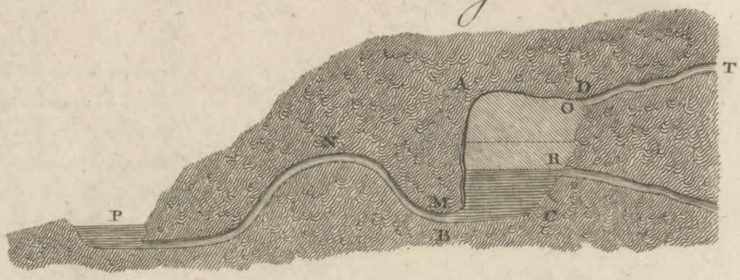


Fig. 77.

Fig. 80.



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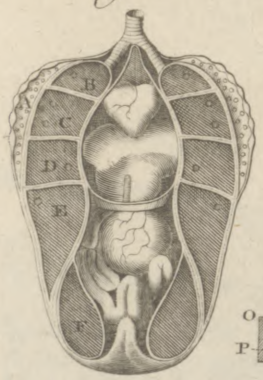

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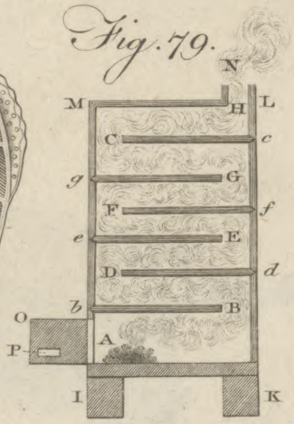

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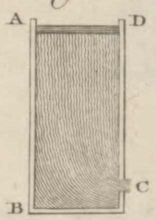

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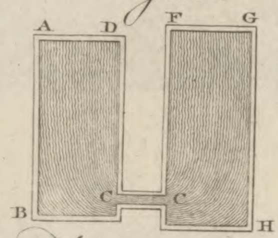

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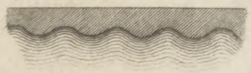

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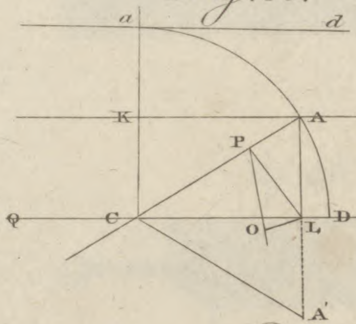

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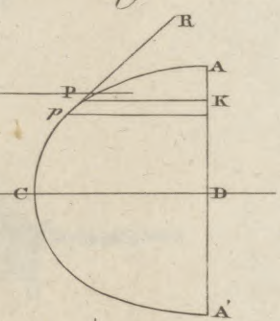

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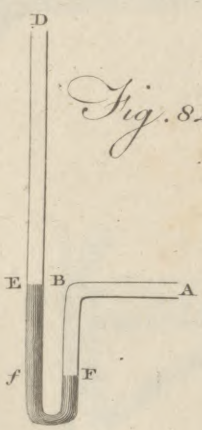

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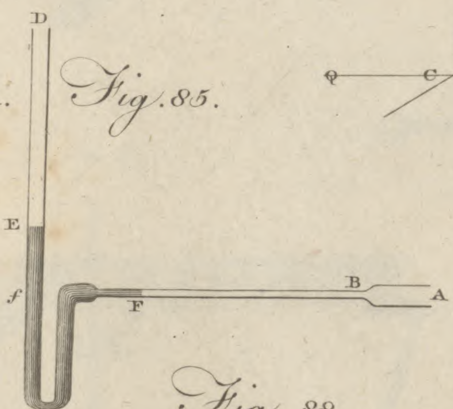

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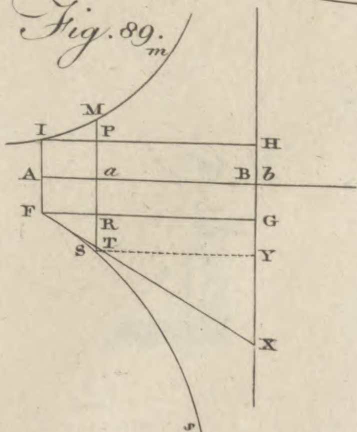

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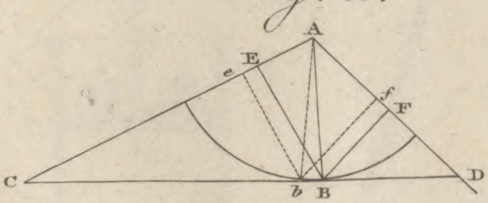


A.Bell Prin. Wal. Sculptor fecit.

Fig. 90.

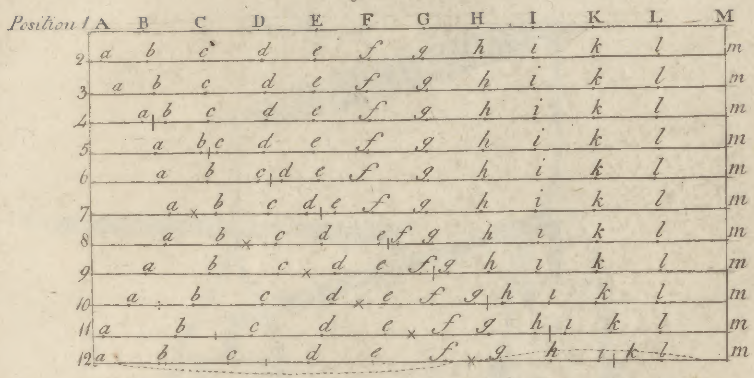
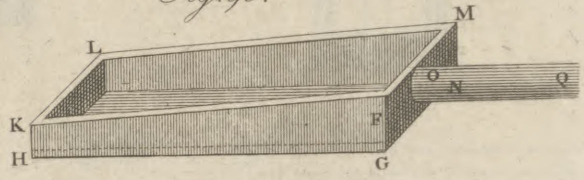


Fig. 91.

Fig. 93.



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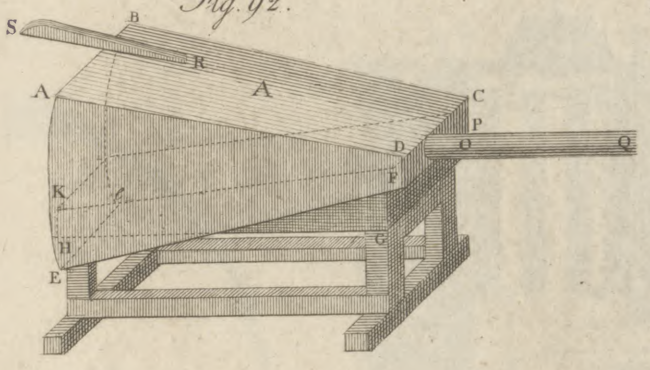

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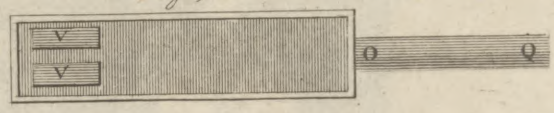

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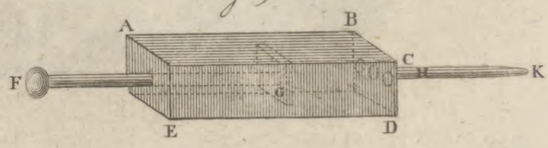

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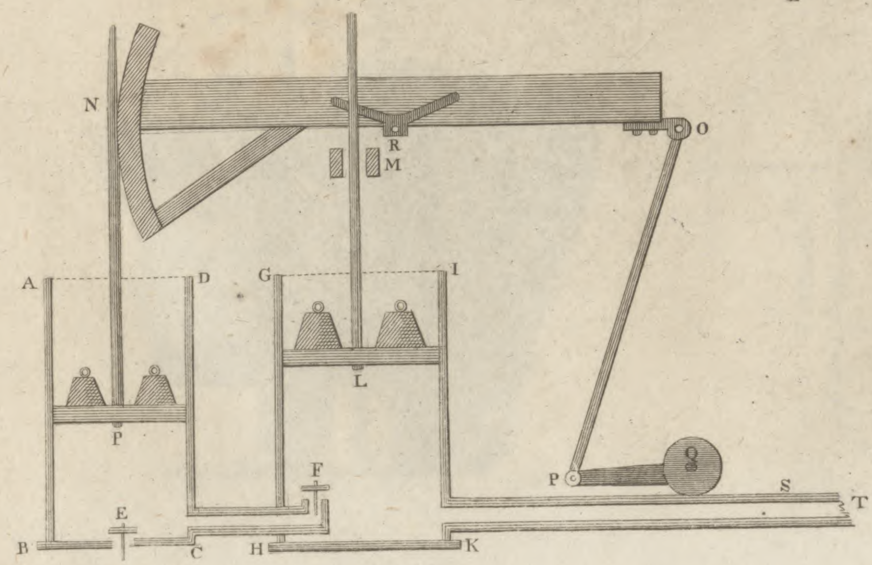
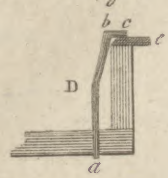
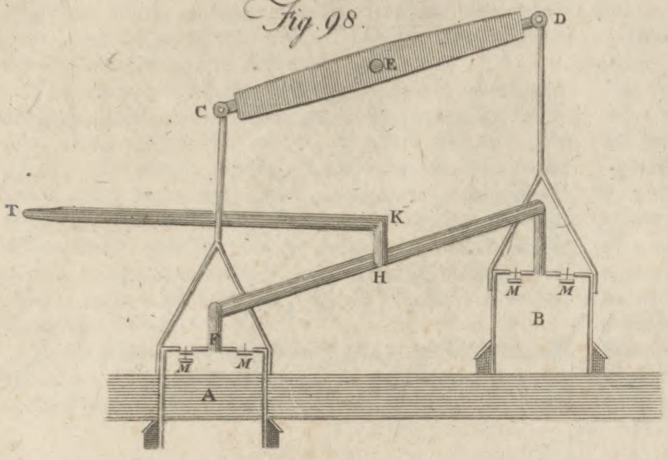


Fig 95



A. Bell Prin Wal Sculptor fecit.

Fig. 98.



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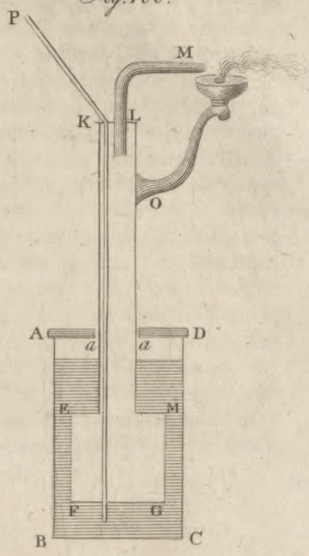

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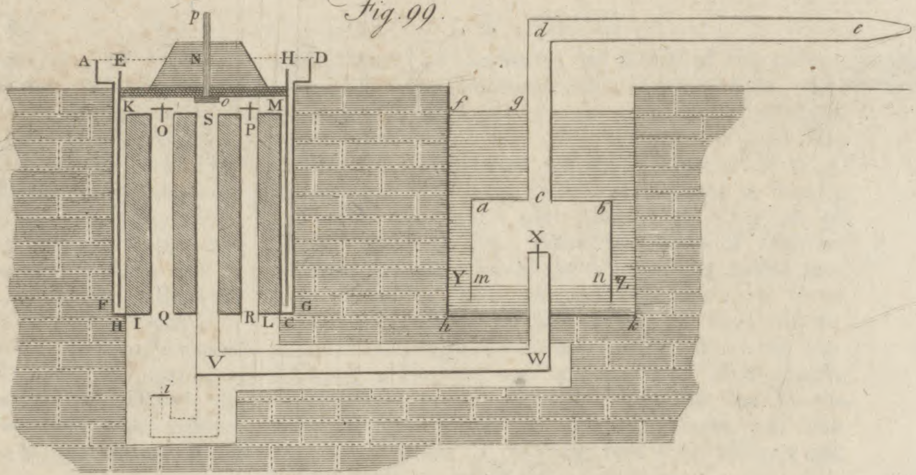

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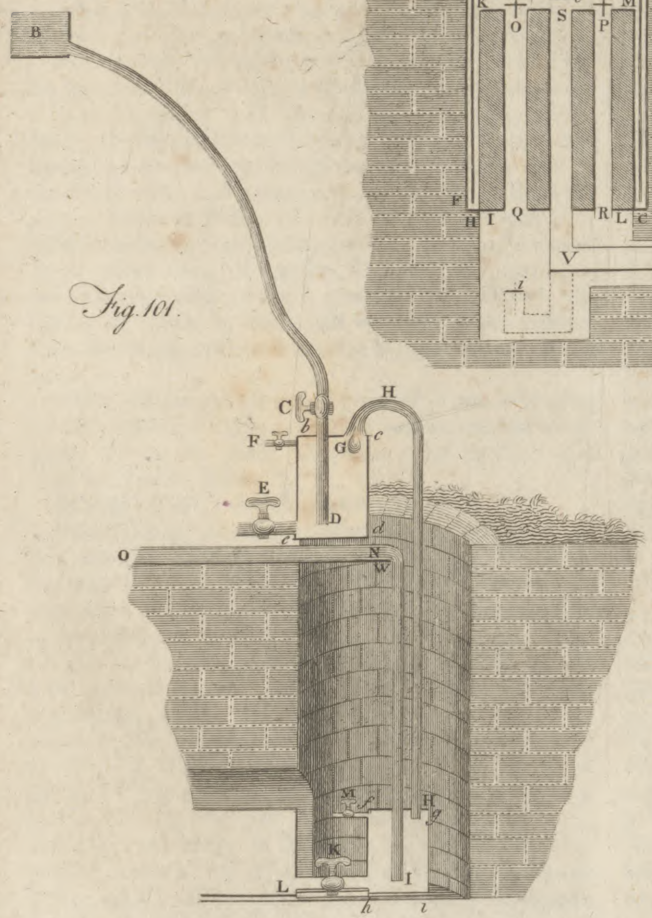

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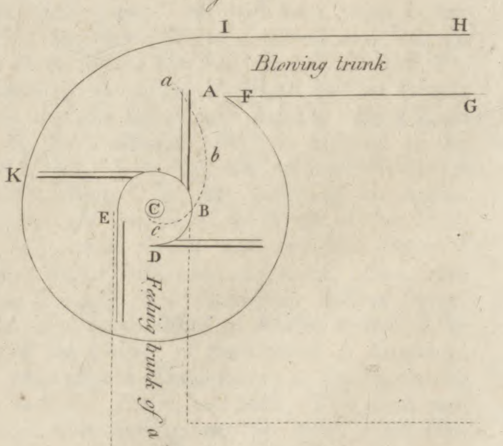

A Bell Prin Wal Sculptor fecit

may offer of making them highly useful. A gentleman's house in the country may thus be supplied with water by a machine that will cost little, and hardly go out of repair.

The last pneumatical engine which we shall speak of at present is the common fanners, used for winnowing grain, and for drawing air out of a room: and we have but few observations to make on them.

Fig. 102. The wings of the fanners are inclosed in a cylinder or drum, whose circular sides have a large opening BDE (fig. 102.) round the centre, to admit the air. By turning the wings rapidly round, the air is hurried round along with them, and thus acquires a centrifugal tendency, by which it presses strongly on the outer rim of the drum: this is gradually detached from the circle as at KI, and terminated in a trunk IHGF, which goes off in a tangential direction; the air therefore is driven along this passage.

If the wings were disposed in planes passing through the axis C, the compression of the air by the anterior surface would give it some tendency to escape in every direction, and would obstruct in some degree the arrival of more air through the side-holes. They are therefore reclined a little backward, as represented in the figure. It may be shown that their best form would be that of a hyperbolic spiral *a b c*; but the straight form approaches sufficiently near to the most perfect shape.

Much labour is lost, however, in carrying the air round those parts of the drum where it cannot escape. The fanners would either draw or discharge almost twice as much air if an opening were made all round one side. This could be gradually contracted (where required for winnowing) by a surrounding cone, and thus directed against the falling grain: this has been verified by actual trial. When used for drawing air out of a room for ventilation, it would be much better to remove the outer side of the drum entirely, and let the air fly freely off on all sides; but the flat sides are necessary, in order to prevent the air from arriving at the fanners any other way but through the central holes, to which trunks should be fitted leading to the apartment which is to be ventilated.

PNEUMATOSIS. See MEDICINE, N° 336.

PNEUMONIA. See MEDICINE, N° 183.

PNEUMONICS, in *Pharmacy*, medicines proper in diseases of the lungs, in which respiration is affected.

PO, a large and celebrated river of Italy, which has its source at Mount Viso in Piedmont, and on the confines of Dauphiny. It runs through Piedmont, Montferrat, the Milanese, and duchy of Mantua; from thence it runs to the borders of the Parmesan, and a part of the Modenese; and having entered the Ferrarese, it begins to divide at Ficheruolo, and proceeds to discharge itself into the gulf of Venice by four principal mouths. As it passes along, it receives several rivers, and often overflows its banks, doing a great deal of mischief: the reason of which is, that most of those rivers descend from the Alps, and are increased by the melting of the snow.

POA, MEADOW-GRASS; a genus of plants belonging to the pentandria class, and in the natural method ranking under the fourth order, *Gramina*. See BOTANY and AGRICULTURE *Index*.

POCHETTI. See BARBATELLI.

POCOCKE, DR EDWARD, a learned oriental scholar, was the eldest son of the Rev. Edward Pococke; and was born at Oxford in 1604, where he was also educated. In 1628 he was admitted probationer-fellow of his college, and about the same time had prepared an edition of the Second Epistle of St Peter, the Second and Third of St John, and that of St Jude, in Syriac and Greek, with a Latin Translation and Notes. In 1629 he was ordained priest, and appointed chaplain to the English merchants at Aleppo, where he continued five or six years; in which time he distinguished himself by his fortitude and zeal while the plague raged there. At length returning to England, he was in 1636 appointed reader of the Arabic lectures founded by Archbishop Laud. Three years after he went to Constantinople, where he prosecuted his studies of the eastern tongues, and procured many valuable manuscripts. After near four years stay in that city, he embarked in 1640; and taking Paris in his way, visited Gabriel Sionita the famous Maronite, and Hugo Grotius. In 1643 he was presented to the rectory of Childrey in Berks; and about three years after married the daughter of Thomas Burdett, Esq. About the middle of 1647 he obtained the restitution of the salary of his Arabic lecture, which had been detained from him about three years. In 1648 King Charles I. who was then prisoner in the isle of Wight, nominated Mr Pococke to the professorship of Hebrew, and the canonry of Christ-church annexed to it; but in 1650 he was ejected from his canonry for refusing to take the engagement, and soon after a vote passed for depriving him of his Hebrew and Arabic lectures; but several governors of houses, &c. presenting a petition in his favour, he was suffered to enjoy both these places. He had some years before published his *Specimen Historiæ Arabum;* and now appeared his *Porta Mosis:* and soon after the English Polyglot edition of the Bible, to which he had largely contributed, and also Eutychius's Annals, with a Latin version. At the Restoration, he was restored to the canonry of Christ-church, and also received the degree of doctor of divinity. He then published his Arabic version of Grotius's Treatise of the Truth of the Christian Religion; and an Arabic poem entitled *Laimato l' Ajam*, with a Latin translation and notes. Soon after he published Gregory Abul Pharajius's *Historia Dynastiarum*. In 1674 he published an Arabic version of the chief parts of the Liturgy of the Church of England; and a few years after his Commentary on the Prophecies of Micah, Malachi, Hosea, and Joel. This great man died in 1691, after having been for many years confessedly the first person in Europe for eastern learning; and was no less worthy of admiration for his uncommon modesty

modesty and humility, and all the virtues that can adorn a Christian. His theological works were republished at London in 1740, in two volumes in folio.

PODAGRA, or the Gout. See Medicine, N° 211.

PODALIRIUS, son of Æsculapius and Epione, was one of the pupils of the Centaur Chiron, under whom he made himself such a master of medicine, that during the Trojan war the Greeks invited him to their camp to stop a pestilence which had baffled the skill of all their physicians. Some suppose, however, that he went to the Trojan war, not in the capacity of a physician in the Grecian army, but as a warrior, attended by his brother Machaon, in 30 ships, with soldiers from Oechalia, Ithome, and Trica. At his return Podalirius was shipwrecked on the coast of Caria, where he cured of the falling sickness a daughter of the king of the place. He fixed his habitation there; and built two towns, one of which he called *Syrna*, after his wife. The Carians, on his death, built him a temple, and paid him divine honours.

PODEX, in *Anatomy*, the same with Anus.

PODGRAJE. See Asisia.

PODOLIA, a province of Poland, bounded on the east by Volhinia and the river Ukrain; on the north and north-east, by Budsiac Tartary; on the south-east, by the river Niester, which separates it from Bessarabia and Moldavia in European Turkey on the south-west; and by the province of Red Russia on the north-west. It is usually divided into the Upper and Lower. In the Upper, which is the western part, the chief town is Kamieck, the capital of Podolia, and of a palatinate. In the Lower or eastern part of Podolia the chief town is Bracklaw, the capital of a palatinate.

PODOPHYLLUM, a genus of plants belonging to the polyandria class; and in the natural method ranking under the 27th order, *Rhœadæ*. See Botany *Index*.

PODURA, or Springtail, a genus of insects of the order of aptera. See Entomology *Index*.

POE-bird is an inhabitant of some of the South sea islands, where it is held in great esteem and veneration by the natives. It goes by the name of *kogo* in New Zealand; but it is better known by that of *poë-bird.* It is somewhat less than our blackbird, and is remarkable for the sweetness of its note, as well as the beauty of its plumage. Its flesh is also delicate food.

POECILE was a famous portico at Athens, which received its name from the variety (ποικιλος) of paintings which it contained. Zeno kept his school there; and there also the stoics received their lessons, whence their name, *ἀ ϛοα, a porch.* The Pœcile was adorned, among many others, with a picture of the siege and sacking of Troy, the battle of Theseus against the Amazons, and the fight between the Lacedæmonians and Athenians at Oenoe in Argolis. The only reward which Miltiades obtained after the battle of Marathon was to have his picture drawn more conspicuous than that of the rest of the officers that fought with him, in the representation which was made of the engagement, and which was hung up in the Pœcile in commemoration of that celebrated victory.

POEM, a poetical composition. See Poetry.

POESTUM, or Posidonia, an ancient city of Grecia Magna, now part of the kingdom of Naples. It was founded by one of those colonies from Greece which in the early ages established themselves in Italy; and it flourished before the foundation of Rome itself. It was destroyed by the Goths on the decline of the Roman empire, who in their barbarous zeal for the Christian religion overturned every place of Pagan worship which was exposed to their ravages. Since that time it has been in ruins; and these ruins were unknown till they were discovered in the following manner: "In the year 1755 (says the author of the *Antiquities, History, and Views of Pœstum*), an apprentice to a painter at Naples, who was on a visit to his friends at Capaccio, by accident took a walk to the mountains which surround the territory of Pœstum. The only habitation he perceived was the cottage of a farmer, who cultivated the best part of the ground, and reserved the rest for pasture. The ruins of the ancient city made a part of this view, and particularly struck the eyes of the young painter; who, approaching nearer, saw with astonishment walls, towers, gates and temples. Upon his return to Capaccio, he consulted the neighbouring people about the origin of these monuments of antiquity. He could only learn, that this part of the country had been uncultivated and abandoned during their memory; that about ten years before, the farmer, whose habitation he had noticed, established himself there; and that having dug in many places and searched among the ruins that lay round him, he had found treasures sufficient to enable him to purchase the whole. At the painter's return to Naples, he informed his master of these particulars, whose curiosity was so greatly excited by the description, that he took a journey to the place, and made drawings of the principal views. These were shown to the king of Naples, who ordered the ruins to be cleared, and Pœstum arose from the obscurity in which it had remained for upwards of 700 years, as little known to the neighbouring inhabitants as to travellers."

Our author gives the following description of it in its present state. It is, says he, of an oblong figure, about two miles and a half in circumference. It has four gates, which are opposite to each other. On the key-stone of the arch of the north gate, on the outside, is the figure of Neptune in basso relievo, and within a hippocampus. The walls which still remain are composed of very large cubical stones, and are extremely thick, in some parts 18 feet. That the walls have remained unto this time is owing to the very exact manner in which the stones are fitted to one another (a circumstance observed universally in the masonry of the ancients), and perhaps in some measure to a stalactical concretion which has grown over them. On the walls here and there are placed towers of different heights; those near the gates being much higher and larger than the others, and evidently of modern workmanship. He observes, that, from its situation among marshes, bituminous and sulphureous springs, Pœstum must have been unwholesome; a circumstance mentioned by Strabo, *Morbosam eam facit fluvius in paludes diffusus.* In such a situation the water must have been bad. Hence the inhabitants were obliged to convey that necessary of life from purer springs by means of aqueducts, of which many vestiges still remain.

The principal monuments of antiquity are a theatre, an amphitheatre, and three temples. The theatre and amphitheatre are much ruined. The first temple is hexastylos, Pœstum. hexaftylos, and amphiproftylos. At one end, the pilafters and two columns which divided the cella from the pronaos are ftill remaining. Within the cella are two rows of fmaller columns, with an architrave, which fupport the fecond order. This temple our author takes to be of that kind called by Vitruvius *hyphæthros*, and fupports his opinion by a quotation from that author. The fecond temple is alfo amphiproftylos: it has nine columns in front and 18 in flank, and feems to be of that kind called by Vitruvius *pfeudodipteros*. The third is likewife amphiproftylos. It has fix columns in front and 13 in flank. Vitruvius calls this kind of temple *peripteros*. "The columns of thefe temples (fays our author) are of that kind of Doric order which we find employed in works of the greateft antiquity. They are hardly five diameters in height. They are without bafes, which alfo has been urged as a proof of their antiquity; but we do not find that the ancients ever ufed bafes to this order, at leaft till very late. Vitruvius makes no mention of bafes for this order: and the only inftance we have of it is in the firft order of the Colifæum at Rome, which was built by Vefpafian. The pillars of thefe temples are fluted with very fhallow flutings in the manner defcribed by Vitruvius. The columns diminifh from the bottom, which was the moft ancient method almoft univerfally in all the orders. The columns have aftragals of a very fingular form; which fhows the error of thofe who imagine that this member was firft invented with the Ionic order, to which the Greeks gave an aftragal, and that the Romans were the firft who applied it to the Doric. The echinus of the Capitol is of the fame form with that of the temple of Corinth defcribed by Le Roy." See *Swinburne's Travels in the Two Sicilies*, vol. ii. p. 131—140. Pœftum, Poet.

POET, the author of a poem. See the article POETRY.

Provençal POETS. See TROUBADOURS.

POETRY.

AMIDST thofe thick clouds which envelope the firft ages of the world, reafon and hiftory throw fome lights on the origin and primitive employment of this divine art. Reafon fuggefts, that before the invention of letters, all the people of the earth had no other method of tranfmitting to their defcendants the principles of their worfhip, their religious ceremonies, their laws, and the renowned actions of their fages and heroes, than by poetry; which included all thefe objects in a kind of hymns that fathers fung to their children, in order to engrave them with indelible ftrokes in their hearts. Hiftory not only informs us, that Mofes and Miriam, the firft authors that are known to mankind, fung, on the borders of the Red fea, a fong of divine praife, to celebrate the deliverance which the Almighty had vouchfafed to the people of Ifrael, by opening a paffage to them through the waters; but it has alfo tranfmitted to us the fong itfelf, which is at once the moft ancient monument and a mafterpiece of poetic compofition.

1 Origin of poetry.

The Greeks, a people the moft ingenious, the moft animated, and in every fenfe the moft accomplifhed, that the world ever produced—ftrove to ravifh from the Hebrews the precious gift of poetry, which was vouchfafed them by the Supreme Author of all nature, that they might afcribe it to their falfe deities. According to their ingenious fictions, Apollo became the god of poetry, and dwelt on the hills of Phocis, Parnaffus, and Helicon, whofe feet were wafhed by the waters of Hippocrene, of which each mortal that ever drank was feized with a facred delirium. The immortal fwans floated on its waves. Apollo was accompanied by the Mufes—thofe nine learned fifters—the daughters of Memory: and he was conftantly attended by the Graces. Pegafus, his winged courfer, tranfported him with a rapid flight into all the regions of the univerfe. Happy emblems! by which we at this day embellifh our poetry, as no one has ever yet been able to invent more brilliant images.

The literary annals of all nations afford veftiges of poetry from the remoteft ages. They are found among the moft favage of the ancient barbarians, and the moft defolate of all the Americans. Nature afferts her rights in every country and every age. Tacitus mentions the verfes and the hymns of the Germans, at the time when that rough people yet inhabited the woods, and while their manners were ftill favage. The firft inhabitants of Runnia and the other northern countries, thofe of Gaul, Albion, Iberia, Aufonia, and other nations of Europe, had their poetry, as well as the ancient people of Afia, and of the known borders of Africa. But the fimple productions of nature have conftantly fomething unformed, rough, and favage. The Divine Wifdom appears to have placed the ingenious and polifhed part of mankind on the earth, in order to refine that which comes from her bofom rude and imperfect: and thus art has polifhed poetry, which iffued quite naked and favage from the brains of the firft of mankind.

But what is Poetry? It would be to abridge the limits of the poetic empire, to contract the fphere of this divine art, fhould we fay, in imitation of all the dictionaries and other treatifes on verfification, That *poetry is the art of making verfes, of lines or periods that are in rhyme or metre*. This is rather a grammatical explanation of the word, than a real definition of the thing, and it would be to degrade poetry thus to define it. The father of criticifm has denominated poetry τεχνη μιμητικη, *an imitative art*: but this, though juft in itfelf, is too general for a definition, as it does not difcriminate poetry from other arts which depend equally on imitation. The jufteft definition feems to be that given by Baron Bielfield *, *That poetry is the art of expreffing our thoughts by fiction*. In fact, it is after this manner (if we reflect with attention) that all the metaphors and allegories, all the various kinds of fiction, form the firft materials of a poetic edifice: it is thus that all images, all comparifons, allufions, and figures, efpecially thofe which perfonify moral fubjects, as virtues and vices, concur to the decoration of fuch a ftructure.

2 Definition of poetry.

* *Elem. of Univ. Erud.*

ſtructure. A work, therefore, that is filled with invention, that inceſſantly preſents images which render the reader attentive and affected, where the author gives intereſting ſentiments to every thing that he makes ſpeak, and where he makes ſpeak by ſenſible figures all thoſe objects which would affect the mind but weakly when clothed in a ſimple proſaic ſtyle, ſuch a work is a poem: While that, though it be in verſe, which is of a didactic, dogmatic, or moral nature, and where the objects are preſented in a manner quite ſimple, without fiction, without images or ornaments, cannot be called *poetry*, but merely a work in verſe; for the art of reducing thoughts, maxims, and periods, into rhyme or metre, is very different from the art of poetry.

An ingenious fable, a lively and intereſting romance, a comedy, the ſublime narrative of the actions of a hero, ſuch as the Telemachus of M. Fenelon, though written in proſe, but in meaſured proſe, is therefore a work of poetry: becauſe the foundation and the ſuperſtructure are the productions of genius, as the whole proceeds from fiction; and truth itſelf appears to have employed an innocent and agreeable deception to inſtruct with efficacy. This is ſo true, that the pencil alſo, in order to pleaſe and affect, has recourſe to fiction; and this part of painting is called the *poetic compoſition of a picture*. It is therefore by the aid of fiction that poetry, ſo to ſpeak, paints its expreſſions, that it gives a body and a mind to its thoughts, that it animates and exalts that which would otherwiſe have remained arid and inſenſible. It is the peculiar privilege of poetry to exalt inanimate things into animals, and abſtract ideas into perſons. The former licence is ſo common, that it is now conſidered as nothing more than a characteriſtical dialect appropriated by the poets to diſtinguiſh themſelves from the writers of proſe; and it is at the ſame time ſo eſſential, that we queſtion much if this ſpecies of compoſition could ſubſiſt without it: for it will perhaps, upon examination, be found, that in every poetical deſcription ſome of the qualities of Animal Nature are aſcribed to things not having life. Every work, therefore, where the thoughts are expreſſed by fictions or images, is poetic; and every work where they are expreſſed naturally, ſimply, and without ornament, although it be in verſe, is proſaic.

Verſe, however, is not to be regarded as foreign or ſuperfluous to poetry. To reduce thoſe images, thoſe fictions, into verſe, is one of the greateſt difficulties in poetry, and one of the greateſt merits in a poem: and for theſe reaſons, the cadence, the harmony of ſounds, particularly that of rhyme, delight the ear to a high degree, and the mind inſenſibly repeats them while the eye reads them. There reſults therefore a pleaſure to the mind, and a ſtrong attachment to theſe ornaments: but this pleaſure would be frivolous, and even childiſh, if it were not attended by a real utility. Verſes were invented in the firſt ages of the world, merely to aid and to ſtrengthen the memory: for cadence, harmony, and eſpecially rhyme, afford the greateſt aſſiſtance to the memory that art can invent; and the images, or poetic fictions, that ſtrike our ſenſes, aſſiſt in graving them with ſuch deep traces in our minds, as even time itſelf frequently cannot efface. How many excellent apophthegms, ſentences, maxims, and precepts, would have been buried in the abyſs of oblivion, if poetry had not preſerved them by its harmony? To give more efficacy to this lively impreſſion, the firſt poets ſung their verſes, and the words and phraſes muſt neceſſarily have been reduced, at leaſt to cadence, or they could not have been ſuſceptible of muſical expreſſion. One of the great excellencies, therefore, though not a neceſſary conſtituent of poetry, conſiſts in its being expreſſed in verſe. See Part III.

3 Verſe, though not eſſential to poetry, one of its excellencies.

Part I. GENERAL PRINCIPLES of the ART.

Sect. I. *Of the Eſſence and End of Poetry.*

4 Eſſence of poetry.

THE *eſſence* of *Polite Arts* in general, and conſequently of poetry in particular, conſiſts in *expreſſion*; and we think that, to be poetic, the expreſſion muſt neceſſarily ariſe from *fiction*, or invention. (See the article Art, particularly from N° 12. to the end.) This invention, which is the fruit of happy genius alone, ariſes, 1. From the ſubject itſelf of which we undertake to treat: 2. From the manner in which we treat that ſubject, or the ſpecies of writing of which we make uſe: 3. From the plan that we propoſe to follow in conformity to this manner; and, 4. From the method of executing this plan in its full detail. Our firſt guides, the ancients, afford us no lights that can elucidate all theſe objects in general. The precepts which Ariſtotle lays down, relate to epic and dramatic poetry only: and which, by the way, confirms our idea, that antiquity itſelf made the eſſence of poetry to conſiſt in fiction, and not in that ſpecies of verſe which is deſtitute of it, or in that which is not capable of it. But ſince this art has riſen to a great degree of perfection; and as poetry, like electricity, communicates its fire to every thing it touches, and animates and embelliſhes whatever it treats; there ſeems to be no ſubject in the univerſe to which poetry cannot be applied, and which it cannot render equally brilliant and pleaſing. From this univerſality of poetry, from its peculiar property of expreſſion by fiction, which is applicable to all ſubjects, have ariſen its different ſpecies, of which a particular deſcription will be given in the *ſecond* part.

Horace, in a well-known verſe, has been ſuppoſed to declare the *end* of poetry to be twofold, to pleaſe, or to inſtruct:

Aut prodeſſe volunt, aut delectare poetæ.

But Dr Beattie * maintains, that the ultimate end of this art is to pleaſe; inſtruction being only one of the means (and not always a neceſſary one) by which that ultimate end is to be accompliſhed. The paſſage rightly underſtood, he obſerves, will not appear to contain any thing inconſiſtent with this doctrine. The author is there ſtating a compariſon between the Greek and Roman writers, with a view to the poetry of the ſtage; and, after commending the former for their correctneſs, and for the liberal ſpirit wherewith they conducted their literary labours, and blaming his countrymen for their inaccuracy

5 End of poetry.

* *Eſſays on Poetry and Muſic*, Part i. chap. i.

Essence and End of Poetry.

inaccuracy and avarice, he proceeds thus: "The ends proposed by our dramatic poets (or by poets in general) are, to please, to instruct, or to do both. When instruction is your aim, let your moral sentences be expressed with brevity, that they may be readily understood, and long remembered: where you mean to please, let your fictions be conformable to truth or probability. The elder part of your audience (or readers) have no relish for poems that give pleasure only without instruction; nor the younger for such writings as give instruction without pleasure. He only can secure the universal suffrage in his favour, who blends the useful with the agreeable, and delights at the same time that he instructs the reader. Such are the works that bring money to the bookseller, that pass into foreign countries, and perpetuate the author's name through a long succession of ages †."—Now, what is the meaning of all this? What, but that to the *perfection* of dramatic poetry (or, if you please, of poetry in general) both sound morals and beautiful fiction are requisite? But Horace never meant to say, that instruction, as well as pleasure, is necessary to give to any composition the *poetical character*; or he would not in another place have celebrated with so much affection and rapture the melting strains of Sappho, and the playful genius of Anacreon ‡,—two authors transcendently sweet, but not remarkably instructive. We are sure, that pathos, and harmony, and elevated language, were, in Horace's opinion, essential to poetry §; and of these decorations nobody will affirm that instruction is the end, who considers that the most instructive books in the world are written in plain prose.

† Hor. Ar. Poet. 333—347.

‡ Hor. Carm. lib. iv. ode 9.

§ Hor. Sat. lib. i. sat. 4. ver. 40.

In short, our author has endeavoured by many ingenious arguments and illustrations to establish it as a truth in criticism, that the end of poetry is *to please*. Verses, if pleasing, may be poetical, though they convey little or no instruction; but verses, whose sole merit it is that they convey instruction, are not poetical. Instruction, however, he admits, especially in poems of length, is necessary to their *perfection*, because they would not be *perfectly agreeable* without it.

Sect. II. *Of the Standard of Poetical Invention.*

6 Poetical invention to be regulated

Homer's beautiful description of the heavens and earth, as they appear in a calm evening by the light of the moon and stars, concludes with this circumstance, "And the heart of the shepherd is glad *." Madame Dacier, from the turn she gives to the passage in her version, seems to think, and Pope, in order perhaps to make out his couplet, insinuates, that the gladness of the shepherd is owing to his sense of the utility of those luminaries. And this may in part be the case: but this is not in Homer; nor is it a necessary consideration. It is true, that, in contemplating the material universe, they who discern the causes and effects of things must be more rapturously entertained than those who perceive nothing but shape and size, colour and motion. Yet, in the mere outside of Nature's work, there is a splendor and a magnificence to which even untutored minds cannot attend without great delight.

* Iliad, viii. 555.

Beattie's Essays, Part i. chap. 2.

Not that all peasants or all philosophers are equally susceptible of these charming impressions. It is strange to observe the callousness of some men, before whom all the glories of heaven and earth pass in daily succession, without touching their hearts, elevating their fancy, or leaving any durable remembrance. Even of those who pretend to sensibility, how many are there to whom the lustre of the rising or setting sun; the sparkling concave of the midnight-sky; the mountain-forest tossing and roaring to the storm, or warbling with all the melodies of a summer-evening; the sweet interchange of hill and dale, shade and sunshine, grove, lawn, and water, which an extensive landscape offers to the view; the scenery of the ocean, so lovely, so majestic, and so tremendous; and the many pleasing varieties of the animal and vegetable kingdoms, could never afford so much real satisfaction, as the steams and noise of a ball-room, the insipid fiddling and squeaking of an opera, or the vexations and wranglings of a card-table!

Of Invention.

But some minds there are of a different make; who, even in the early part of life, receive from the contemplation of Nature a species of delight which they would hardly exchange for any other, and who, as avarice and ambition are not the infirmities of that period, would, with equal sincerity and rapture, exclaim,

> I care not, Fortune, what you me deny;
> You cannot rob me of free Nature's grace;
> You cannot shut the windows of the sky,
> Through which Aurora shows her bright'ning face;
> You cannot bar my constant feet to trace
> The woods and lawns by living stream at eve.
>
> *Castle of Indolence.*

Such minds have always in them the seeds of true taste, and frequently of imitative genius. At least, though their enthusiastic or visionary turn of mind (as the man of the world would call it) should not always incline them to practise poetry or painting, we need not scruple to affirm, that without some portion of this enthusiasm no person ever became a true poet or painter. For he who would imitate the works of nature, must first accurately observe them; and accurate observation is to be expected from those only who take great pleasure in it.

To a mind thus disposed no part of creation is indifferent. In the crowded city and howling wilderness; in the cultivated province and solitary isle; in the flowery lawn and craggy mountain; in the murmur of the rivulet and in the uproar of the ocean; in the radiance of summer and gloom of winter; in the thunder of heaven and in the whisper of the breeze; he still finds something to rouze or to soothe his imagination, to draw forth his affections, or to employ his understanding. And from every mental energy that is not attended with pain, and even from some of those that are, as moderate terror and pity, a sound mind derives satisfaction; exercise being equally necessary to the body and the soul, and to both equally productive of health and pleasure.

This happy sensibility to the beauties of nature should be cherished in young persons. It engages them to contemplate the Creator in his wonderful works; it purifies and harmonizes the soul, and prepares it for moral and intellectual discipline; it supplies an endless source of amusement; it contributes even to bodily health: and, as a strict analogy subsists between material and moral beauty, it leads the heart by an easy transition from the one to the other; and thus recommends virtue for its transcendant loveliness, and makes vice appear the

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object of contempt and abomination. An intimate acquaintance with the best descriptive poets, Spenser, Milton, and Thomson, but above all with the divine Georgic, joined to some practice in the art of drawing, will promote this amiable sensibility in early years: for then the face of nature has novelty superadded to its other charms, the passions are not pre-engaged, the heart is free from care, and the imagination warm and romantic.

7 by the standard of nature.

But not to insist longer on those ardent emotions that are peculiar to the enthusiastic disciple of nature, may it not be affirmed of all men, without exception, or at least of all the enlightened part of mankind, that they are gratified by the contemplation of things natural, as opposed to unnatural? Monstrous sights please but for a moment, if they please at all; for they derive their charm from the beholder's amazement, which is quickly over. We read indeed of a man of rank in Sicily *, who chooses to adorn his villa with pictures and statues of most unnatural deformity: but it is a singular instance; and one would not be much more surprised to hear of a person living without food, or growing fat by the use of poison. To say of any thing, that it is *contrary to nature*, denotes censure and disgust on the part of the speaker; as the epithet *natural* intimates an agreeable quality, and seems for the most part to imply, that a thing is as it ought to be, suitable to our own taste, and congenial with our own constitution. Think with what sentiments we should peruse a poem, in which nature was totally misrepresented, and principles of thought and of operation supposed to take place, repugnant to every thing we had seen or heard of:—in which, for example, avarice and coldness were ascribed to youth, and prodigality and passionate attachment to the old; in which men were made to act at random, sometimes according to character, and sometimes contrary to it; in which cruelty and envy were productive of love, and beneficence and kind affection of hatred: in which beauty was invariably the object of dislike, and ugliness of desire; in which society was rendered happy by atheism and the promiscuous perpetration of crimes, and justice and fortitude were held in universal contempt. Or think, how we should relish a painting, where no regard was had to the proportions, colours, or any of the physical laws, of Nature:—where the ears and eyes of animals were placed in their shoulders; where the sky was green and the grass crimson; where trees grew with their branches in the earth and their roots in the air; where men were seen fighting after their heads were cut off, ships sailing on the land, lions entangled in cobwebs, sheep preying on dead carcases, fishes sporting in the woods, and elephants walking on the sea. Could such figures and combinations give pleasure, or merit the appellation of sublime or beautiful? Should we hesitate to pronounce their author mad? And are the absurdities of madmen proper subjects either of amusement or of imitation to reasonable beings?

* *Brydone's Tour in Sicily*, let. 24.

Let it be remarked, too, that though we distinguish our internal powers by different names, because otherwise we could not speak of them so as to be understood, they are all but so many energies of the same individual mind; and therefore it is not to be supposed, that what contradicts any one leading faculty should yield permanent delight to the rest. That cannot be agreeable to reason, which conscience disapproves; nor can that gratify imagination, which is repugnant to reason.——Besides, belief and acquiescence of mind are pleasant, as distrust and disbelief are painful: and therefore, that only can give solid and general satisfaction, which has something of plausibility in it; something which we conceive it possible for a rational being to believe. But no rational being can acquiesce in what is obviously contrary to nature, or implies palpable absurdity.

Poetry, therefore, and indeed every art whose end is to please, must be natural; and if so, must exhibit real matter of fact, or something like it; that is, in other words, must be either according to truth or according to verisimilitude.

And though every part of the material universe abounds in objects of pleasurable contemplation, yet nothing in nature so powerfully touches our hearts, or gives so great variety of exercise to our moral and intellectual faculties, as man. Human affairs and human feelings are universally interesting. There are many who have no great relish for the poetry that delineates only irrational or inanimate beings; but to that which exhibits the fortunes, the characters, and the conduct of men, there is hardly any person who does not listen with sympathy and delight. And hence to imitate human action, is considered by Aristotle as essential to this art; and must be allowed to be essential to the most pleasing and most instructive part of it, Epic and Dramatic composition. Mere descriptions, however beautiful, and moral reflections, however just, become tiresome, where our passions are not occasionally awakened by some event that concerns our fellow-men. Do not all readers of taste receive peculiar pleasure from those little tales or episodes with which Thomson's descriptive poem on the Seasons is here and there enlivened? and are they not sensible, that the thunder-storm would not have been half so interesting without the tale of the two lovers (*Summ.* v. 1171); nor the harvest-scene, without that of Palemon and Lavinia (*Aut.* v. 177.); nor the driving snows, without that exquisite picture of a man perishing among them (*Winter*, v. 276.)? It is much to be regretted, that Young did not employ the same artifice to animate his Night-Thoughts. Sentiments and descriptions may be regarded as the pilasters, carvings, gildings, and other decorations of the poetical fabric: but human actions are the columns and the rafters that give it stability and elevation. Or, changing the metaphor, we may consider these as the soul which informs the lovely frame; while those are little more than the ornaments of the body.

Whether the pleasure we take in things natural, and our dislike to what is the reverse, be the effect of habit or of constitution, is not a material inquiry. There is nothing absurd in supposing, that between the soul, in its first formation, and the rest of nature, a mutual harmony and sympathy may have been established, which experience may indeed confirm, but no perverse habits could entirely subdue. As no sort of education could make man believe the contrary of a self-evident axiom, or reconcile him to a life of perfect solitude, so we should imagine, that our love of nature and regularity might still remain with us in some degree, though we had been born and bred in the Sicilian villa above-mentioned, and never heard any thing applauded but what deserved censure, nor censured but what merited applause. Yet habit must be allowed to have a powerful influence over the

8 Habit has great influence over sentiment and feeling, and of course upon poetry.

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the sentiments and feelings of mankind; for objects to which we have been long accustomed, we are apt to contract a fondness: we conceive them readily, and contemplate them with pleasure; nor do we quit our old tracts of speculation or practice without reluctance and pain. Hence in part arises our attachment to our own professions, our old acquaintance, our native soil, our homes, and to the very hills, streams, and rocks in our neighbourhood. It would therefore be strange, if man, accustomed as he is from his earliest days to the regularity of nature, did not contract a liking to her productions and principles of operation.

9
No necessity that the poet should exactly copy nature.

Yet we neither expect nor desire, that every human invention, where the end is only to please, should be an exact transcript of real existence. It is enough, that the mind acquiesce in it as probable or plausible, or such as we think might happen without any direct opposition to the laws of nature:—Or, to speak more accurately, it is enough that it be consistent, either, first, with general experience; or, secondly, with popular opinion; or, thirdly, that it be consistent with itself, and connected with probable circumstances.

First: If a human invention be consistent with *general* experience, we acquiesce in it as sufficiently probable. *Particular* experiences, however, there may be, so uncommon, and so little expected, that we should not admit their probability, if we did not know them to be true. No man of sense believes, that he has any likelihood of being enriched by the discovery of hidden treasure; or thinks it probable, on purchasing a lottery-ticket, that he shall gain the first prize; and yet great wealth has actually been acquired by such good fortune. But we should look upon these as poor expedients in a play or romance for bringing about a happy catastrophe. We expect that fiction should be more consonant to the general tenor of human affairs; in a word, that not possibility, but probability, should be the standard of poetical invention.

10
Fiction sufficiently conformable to nature when it accords with received opinions,

Secondly: Fiction is admitted as conformable to this standard, when it accords with received opinions. These may be erroneous, but are not often *apparently* repugnant to natnre. On this account, and because they are familiar to us from our infancy, the mind readily acquiesces in them, or at least yields them that degree of credit which is necessary to render them pleasing: hence the fairies, ghosts, and witches of Shakespeare, are admitted as probable beings; and angels obtain a place in religious pictures though we know that they do not now appear in the scenery of real life. A poet who should at this day make the whole action of his tragedy depend upon enchantment, and produce the chief events by the assistance of supernatural agents, would indeed be censured as transgressing the bounds of probability, be banished from the theatre to the nursery, and condemned to write fairy tales instead of tragedies. But Shakespeare was in no danger of such censures: In his days the doctrine of witchcraft was established both by law and by the fashion; and it was not only unpolite, but criminal, to doubt it. Now indeed it is admitted only by the vulgar; but it does not therefore follow that an old poem built upon it should not be acceptable to the learned themselves. When a popular opinion has long been exploded, and has become repugnant to philosophical belief, the fictions built upon it are still admitted as natural, both because we all remember to have listened to them in childhood with some degree of credit, and because we know that they were accounted natural by the people to whom they were first addressed; whose sentiments and views of things we are willing to adopt, when, by the power of pleasing description, we are introduced into their scenes, and made acquainted with their manners. Hence we admit the theology of the ancient poets, their Elysium and Tartarus, Scylla and Charybdis, Cyclops and Circe, and the rest of those "beautiful wonders" (as Horace calls them) which were believed in the heroic ages; as well as the demons and enchantments of Tasso, which may be supposed to have obtained no small degree of credit among the Italians of the 16th century, and are suitable enough to the notions that prevailed universally in Europe not long before (A). In fact, when poetry is in other respects true, when it gives an accurate display of those parts of nature about which we know that men in all ages must have entertained the same opinion, namely, those appearances in the visible creation, and those feelings and working of the human mind, which are obvious to all mankind;—when poetry is thus far according to nature, we are very willing to be indulgent to what is fictitious in it, and to grant a temporary allowance to any system of fable which the author pleases to adopt; provided that he lay the scene in a distant country, or fix the date to a remote period. This is no unreasonable piece of complaisance; we owe it both to the poet and to ourselves; for without it we should neither form a right estimate of his genius, nor receive from his works that pleasure which they were intended to impart. Let him, however, take care, that his system of fable be such as his countrymen and cotemporaries (to whom his work is immediately addressed) might be supposed capable of yielding their assent to; for otherwise we should not believe him to be in earnest: and let him connect it as much as he can with probable circumstances, and make it appear in a series of events consistent with itself.

For (thirdly) if this be the case, we shall admit his story as probable, or at least as natural, and consequently be interested in it, even though it be not warranted by general experience, and derive but slender authority from popular opinion. Calyban, in the Tempest, would have shocked the mind as an improbability, if we had not been made acquainted with his origin, and seen his character displayed in a series of consistent behaviour. But when we are told that he sprung from a witch and a demon, a connection not contrary to the laws of nature, as they were understood in Shakespeare's time, and find his manners conformable to his descent, we are easily reconciled to the fiction. In the same sense, the Lilliputians of

(A) In the 14th century, the common people of Italy believed that the poet Dante went down to hell; that the *Inferno* was a true account of what he saw there; and that his sallow complexion, and stunted beard (which seemed by its growth and colour to have been too near the fire), were the consequence of his passing so much of his time in that hot and smoky region. See *Vicende della Literatura del Sig. C. Denina*, cap. 4.

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of Swift may pass for probable beings; not so much because we know that a belief in pigmies was once current in the world (for the true ancient pigmy was at least thrice as tall as those whom Gulliver visited), but because we find that every circumstance relating to them accords with itself, and with their supposed character.

11 and is consistent with itself.

It is not the size of the people only that is diminutive; their country, seas, ships, and towns, are all in exact proportion; their theological and political principles, their passions, manners, customs, and all the parts of their conduct, betray a levity and littleness perfectly suitable; and so simple is the whole narration, and apparently so artless and sincere, that we should not much wonder if it had imposed (as we have been told it has) upon some persons of no contemptible understanding. The same degree of credit may perhaps for the same reasons be due to his giants. But when he grounds his narrative upon a contradiction to nature; when he presents us with rational brutes, and irrational men; when he tells us of horses building houses for habitation, milking cows for food, riding in carriages, and holding conversations on the laws and politics of Europe; not all his genius (and he there exerts it to the utmost) is able to reconcile us to so monstrous a fiction: we may smile at some of his absurd exaggerations; we may be pleased with the energy of style, and accuracy of description, in particular places; and a malevolent heart may triumph in the satire; but we can never relish it as a fable, because it is at once unnatural and self-contradictory. Swift's judgement seems to have forsaken him on this occasion: he wallows in nastiness and brutality: and the general run of his satire is downright defamation. Lucian's *True History*, is a heap of extravagancies put together without order or unity, or any other apparent design than to ridicule the language and manner of grave authors. His ravings, which have no better right to the name of *fable*, than a hill of rubbish has to that of palace, are destitute of every colour of plausibility. Animal trees, ships sailing in the sky, armies of monstrous things travelling between the sun and moon on a pavement of cobwebs, rival nations of men inhabiting woods and mountains in a whale's belly,—are liker the dreams of a bedlamite than the inventions of a rational being.

Beattie's Essays, ut supra.

12 A stricter probability requisite in some kinds of poetry than in others.

If we were to prosecute this subject any farther, it would be proper to remark, that in some kinds of poetical invention a stricter probability is required than in others:—that, for instance, Comedy, whether dramatic or narrative (B), must seldom deviate from the ordinary course of human affairs, because it exhibits the manners of real and even of familiar life:—that the tragic poet, because he imitates characters more exalted, and generally refers to events little known, or long since past, may be allowed a wider range; but must never attempt the marvellous fictions of the epic muse, because he addresses his work, not only to the passions and imagination of mankind, but also to their eyes and ears, which are not easily imposed on, and refuse to be gratified with any representation that does not come very near the truth:—that the epic poem may claim still ampler privileges, because its fictions are not subject to the scrutiny of any outward sense, and because it conveys information in regard both to the highest human characters, and the most important and wonderful events, and also to the affairs of unseen worlds and superior beings. Nor would it be improper to observe, that the several species of comic, of tragic, of epic composition, are not confined to the same degree of probability; for that farce may be allowed to be less probable than the regular comedy; the masque than the regular tragedy; and the mixed epic, such as the Fairy Queen, and Orlando Furioso, than the pure epopee of Homer, Virgil, and Milton. But this part of the subject seems not to require further illustration. Enough has been said to show, that nothing unnatural can please; and that therefore poetry, whose end is to please, must be *according to nature*.

And if so, it must be either according to real nature, or according to nature somewhat different from the reality.

SECT. III. *Of the System of Nature exhibited by Poetry.*

To exhibit *real nature* is the business of the historian; who, if he were strictly to confine himself to his own sphere, would never record even the minutest circumstance of any speech, event, or description, which was not warranted by sufficient authority. It has been the language of critics in every age, that the historian ought to relate nothing as true which is false or dubious, and to conceal nothing material which he knows to be true. But it is to be doubted whether any writer of profane history has ever been so scrupulous. Thucydides himself, who began his history when that war began which he records, and who set down every event soon after it happened, according to the most authentic information, seems, however, to have indulged his fancy not a little in his harangues and descriptions, particularly that of the plague of Athens: and the same thing has been practised, with greater latitude, by Livy and Tacitus, and more or less by all the best historians both ancient and modern. Nor are they to be blamed for it. By these improved or invented speeches, and by the heightenings thus given to their descriptions, their work becomes more interesting, and more useful; nobody is deceived, and historical truth is not materially affected. A medium is, however, to be observed in this, as in other things. When the historian lengthens a description into a detail of fictitious events, as Voltaire has done in his account of the battle of Fontenoy, he loses his credit with us, by raising a suspicion that he is more intent upon a pretty story than upon the truth. And we are disgusted with his insincerity, when, in defiance even of verisimilitude, he puts long elaborate orations in the mouth of those, of whom we know, either from the circumstances that they could not, or from more authentic records that they did not, make any such orations; as Dionysius of Halicarnassus has done in the case of Volumnia haranguing her son Coriolanus, and Flavius Josephus in that of Judah addressing his brother as viceroy of Egypt. From what these historians relate, one would conjecture

13 Historians embellish their works by fiction, and make them

(B) Fielding's *Tom Jones*, *Amelia*, and *Joseph Andrews*, are examples of what may be called the *Epic* or *Narrative Comedy*, or more properly perhaps the *Comic Epopee*.

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conjecture that the Roman matron had studied at Athens under some long-winded rhetorician, and that the Jewish patriarch must have been one of the most flowery orators of antiquity. But the fictitious part of history, or of story-telling, ought never to take up much room; and must be highly blameable when it leads into any mistake either of facts or of characters.

14 In some degree poetical.

Now, why do historians take the liberty to embellish their works in this manner? One reason, no doubt, is, that they may display their talents in oratory and narration: but the chief reason, as hinted already, is, to render their composition more agreeable. It would seem, then, that something more pleasing than real nature, or something which shall add to the pleasing qualities of real nature, may be devised by human fancy. And this may certainly be done. And this it is the poet's business to do. And when this is in any degree done by the historian, his narrative becomes in that degree poetical.

The possibility of thus improving upon nature must be obvious to every one. When we look at a landscape, we can fancy a thousand additional embellishments. Mountains loftier and more picturesque; rivers more copious, more limpid, and more beautifully winding; smoother and wider lawns; valleys more richly diversified; caverns and rocks more gloomy and more stupendous; ruins more majestic; buildings more magnificent; oceans more varied with islands, more splendid with shipping, or more agitated by storm, than any we have ever seen—it is easy for human imagination to conceive. Many things in art and nature exceed expectation; but nothing sensible transcends or equals the capacity of thought:—a striking evidence of the dignity of the human soul! The finest woman in the world appears to every eye susceptible of improvement, except perhaps to that of her lover. No wonder, then, if in poetry events can be exhibited more compact, and of more pleasing variety, than those delineated by the historian, and scenes of inanimate nature more dreadful or more lovely, and human characters more sublime and more exquisite, both in good and evil. Yet still let nature supply the ground-work and materials, as well as the standard, of poetical fiction. The most expert painters use a layman, or other visible figure, to direct their hand and regulate their fancy. Homer himself founds his two poems on authentic tradition; and tragic as well epic poets have followed the example. The writers of romance, too, are ambitious to interweave true adventures with their fables; and when it can be conveniently done, to take the outlines of their plan from real life. Thus the tale of Robinson Crusoe is founded on an incident that actually befel one Alexander Selkirk, a seafaring man, who lived several years alone in the island of Juan Fernandes: Smollet is thought to have given us several of his own adventures in the history of Roderic Random; and the chief characters in Tom Jones, Joseph Andrews, and Pamela, are said to have been copied from real originals. Dramatic comedy, indeed, is for the most part purely fictitious: for if it were to exhibit real events as well as present manners, it would become too personal to be endured by a well-bred audience, and degenerate into downright abuse; which appears to have been the case with the old comedy of the Greeks *. But in general, hints taken from real existence will be found to give no little grace and stability to fiction, even in the most fanciful poems. These hints, however, may be improved by the poet's imagination, and set off with every probable ornament that can be devised, consistently with the design and genius of the work; or in other words, with the sympathies that the poet means to awaken in the mind of his reader. For mere poetical ornament, when it fails to interest the affections, is not only useless, but improper; all true poetry being addressed to the heart, and intended to give pleasure by raising or soothing the passions;—the only effectual way of pleasing a rational and moral creature. And therefore we would take Horace's maxim to be universal in poetry:" "*Non satis est, pulchra esse poemata;* dulcia *sunto:*" "It is not enough that poems be beautiful; let them also be *affecting:*"—For that this is the meaning of the word *dulcia* in this place, is admitted by the best interpreters, and is indeed evident from the context †.

Beattie's *Essays*, chap. ii.

15 Poets embellish nature itself,

* Compare *Hor.* lib. i. sat. 4. vers. 1.—5. with *Ar. Poet.* vers. 281.—285.

† *Hor. Ar. Poet* vers. 95.—100.

16 and describe even things inanimate so as to make them affecting.

That the sentiments and feelings of percipient beings when expressed in poetry, should call forth our affections, is natural enough; but can descriptions of inanimate things also be made affecting? certainly they can: and the more they affect, the more they please us, and the more poetical we allow them to be. Virgil's Georgic is a noble specimen (and indeed the noblest in the world) of this sort of poetry. His admiration of external nature gains upon a reader of taste, till it rise to perfect enthusiasm. The following observations will perhaps explain this matter.

Every thing in nature is complex in itself, and bears innumerable relations to other things; and may therefore be viewed in an endless variety of lights, and consequently described in an endless variety of ways. Some descriptions are good, and others bad. An historical description, that enumerates all the qualities of any object, is certainly good, because it is true; but may be as unaffecting as a logical definition. In poetry, no unaffecting description is good however conformable to truth: for here we expect not a complete enumeration of qualities (the chief end of the art being to please), but only such an enumeration as may give a lively and interesting idea. It is not memory, or the knowledge of rules, that can qualify a poet for this sort of description; but a peculiar liveliness of fancy and sensibility of heart, the nature whereof we may explain by its effects, but we cannot lay down rules for the attainment of it.

When our mind is occupied by any emotion, we naturally use words and meditate on things that are suitable to it and tend to encourage it. If a man were to write a letter when he is very angry, there would probably be something of vehemence or bitterness in the style, even though the person to whom he wrote were not the object of his anger. The same thing holds true of every other strong passion or emotion:—while it predominates in the mind, it gives a peculiarity to our thoughts, as well as to our voice, gesture, and countenance: And hence we expect, that every personage introduced in poetry should see things through the medium of his ruling passion, and that his thoughts and language should be tinctured accordingly. A melancholy man walking in a grove, attends to those things that suit and encourage his melancholy; the sighing of the wind in the trees, the murmuring of waters, the darkness and solitude of the shades: A cheerful man in the

17 Every person introduced in poetry should see things through the medium of his ruling passion.

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the ſame place, finds many ſubjects of cheerful meditations, in the ſinging of birds, the briſk motions of the babbling ſtream, and the livelineſs and variety of the verdure. Perſons of different characters, contemplating the ſame thing, a Roman triumph, for inſtance, feel different emotions, and turn their view to different objects. One is filled with wonder at ſuch a diſplay of wealth and power; another exults in the idea of conqueſt, and pants for military renown; a third, ſtunned with clamour, and haraſſed with confuſion, wiſhes for ſilence, ſecurity, and ſolitude; one melts with pity to the vanquiſhed, and makes many a ſad reflection upon the inſignificance of worldly grandeur, and the uncertainty of human things; while the buffoon, and perhaps the philoſopher, conſiders the whole as a vain piece of pageantry, which, by its ſolemn procedure, and by the admiration of ſo many people, is only rendered the more ridiculous:—and each of theſe perſons would deſcribe it in a way ſuitable to his own feelings, and tending to raiſe the ſame in others. We ſee in Milton's Allegro and Penſoroſo, how a different caſt of mind produces a variety in the manner of conceiving and contemplating the ſame rural ſcenery. In the former of theſe excellent poems, the author perſonates a cheerful man, and takes notice of thoſe things in external nature that are ſuitable to cheerful thoughts, and tend to encourage them: in the latter, every object deſcribed is ſerious and ſolemn, and productive of calm reflection and tender melancholy; and we ſhould not be eaſily perſuaded, that Milton wrote the firſt under the influence of ſorrow, or the ſecond under that of gladneſs. We often ſee an author's character in his works; and if every author were in earneſt when he writes, we ſhould oftener ſee it. Thomſon was a man of piety and benevolence, and a warm admirer of the beauties of nature; and every deſcription in his delightful poem on the Seaſons tends to raiſe the ſame laudable affections in his reader. The parts of nature that attract his notice are thoſe which an impious or hard-hearted man would neither attend to, nor be affected with, at leaſt in the ſame manner. In Swift we ſee a turn of mind very different from that of the amiable Thomſon; little reliſh for the ſublime or beautiful, and a perpetual ſucceſſion of violent emotions. All his pictures of human life ſeem to ſhow, that deformity and meanneſs were the favourite objects of his attention, and that his ſoul was a conſtant prey to indignation (c), diſguſt, and other gloomy paſſions, ariſing from ſuch a view of things. And it is the tendency of almoſt all his writings (though it was not always the author's deſign), to communicate the ſame paſſions to his reader: inſomuch, that notwithſtanding his erudition and knowledge of the world, his abilities as a popular orator and man of buſineſs, the energy of his ſtyle, the elegance of ſome of his verſes, and his extraordinary talents in wit and humour, there is reaſon to doubt, whether by ſtudying his works any perſon was very much improved in piety or benevolence.

Beattie's Eſſays, ut ſupra.

And thus we ſee, how the compoſitions of an ingenious author may operate upon the heart, whatever be the ſubject. The affections that prevail in the author himſelf, direct his attention to objects congenial, and give a peculiar bias to his inventive powers, and a peculiar colour to his language. Hence his work, as well as face, if nature is permitted to exert herſelf freely in it, will exhibit a picture of his mind, and awaken correſpondent ſympathies in the reader. When theſe are favourable to virtue, which they always ought to be, the work will have that ſweet pathos to which Horace alludes in the paſſage above mentioned; and which we ſo highly admire, and ſo warmly approve, even in thoſe parts of the Georgic that deſcribe inanimate nature.

18 It is thus that poetry affects the heart whatever be its ſubject.

Horace's account of the matter in queſtion differs not from what is here given. "It is not enough (ſays he*) that poems be beautiful; let them be affecting, and agitate the mind with whatever paſſions the poet wiſhes to impart. The human countenance, as it ſmiles on thoſe who ſmile, accompanies alſo with ſympathetic tears thoſe who mourn. If you would have me weep, you muſt firſt weep yourſelf; then, and not before, ſhall I be touched with your misfortunes.—For nature firſt makes the emotions of our mind correſpond with our circumſtances, infuſing real joy, ſorrow, or reſentment, according to the occaſion; and afterwards gives the true pathetic utterance to the voice and language." This doctrine, which concerns the orator and the player no leſs than the poet, is ſtrictly philoſophical, and equally applicable to dramatic, to deſcriptive, and indeed to every ſpecies of intereſting poetry. The poet's ſenſibility muſt firſt of all engage him warmly in his ſubject, and in every part of it; otherwiſe he will labour in vain to intereſt the reader. If he would paint external nature, as Virgil and Thomſon have done, ſo as to make her amiable to others, he muſt firſt be enamoured of her himſelf; if he would have his heroes and heroines ſpeak the language of love or ſorrow, devotion or courage, ambition or anger, benevolence or pity, his heart muſt be ſuſceptible of thoſe emotions, and in ſome degree feel them, as long at leaſt as he employs himſelf in framing words for them; being aſſured, that

* *Ar. Poet.* v. 99.—111

He beſt ſhall paint them who can feel them moſt.
Pope's *Eloiſa*, v. 366.

19 The true poet muſt poſſeſs fancy to invent decorations to nature.

The true poet, therefore, muſt not only ſtudy nature, and know the reality of things, but muſt alſo poſſeſs fancy, to invent additional decorations; judgment, to direct him in the choice of ſuch as accord with veriſimilitude; and ſenſibility, to enter with ardent emotions into every part of his ſubject, ſo as to transfuſe into every part of his work a pathos and energy ſufficient to raiſe correſponding emotions in the reader.

"The hiſtorian and the poet (ſays Ariſtotle*) differ in this, that the former exhibits things as they are, the latter as they might be;"—*i. e.* in that ſtate of perfection which is conſiſtent with probability, and in which, for the ſake of our own gratification, we wiſh to find them. If the poet, after all the liberties he is allowed to take with the truth, can produce nothing more exquiſite than is commonly to be met with in hiſtory, his reader

* *Poetic.* ſect. 9.

(c) For part of this remark we have his own authority, often in his letters, and very explicitly in the Latin epitaph which he compoſed for himſelf:—" ubi ſæva indignatio ulterius cor lacerare nequit." *See his laſt will and teſtament.*

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reader will be disappointed and dissatisfied. Poetical representations must therefore be framed after a pattern of the highest probable perfection that the genius of the work will admit:—external nature must in them be more picturesque than in reality; action more animated; sentiments more expressive of the feelings and character, and more suitable to the circumstances of the speaker; personages better accomplished in those qualities that raise admiration, pity, terror, and other ardent emotions; and events more compact, more clearly connected with causes and consequences, and unfolded in an order more flattering to the fancy, and more interesting to the passions. But where, it may be said, is this pattern of perfection to be found? Not in real nature; otherwise history, which delineates real nature, would also delineate this pattern of perfection. It is to be found only in the mind of the poet; and it is imagination, regulated by knowledge, that enables him to form it.

In the beginning of life, and while experience is confined to a small circle, we admire every thing, and are pleased with very moderate excellence. A peasant thinks the hall of his landlord the finest apartment in the universe, listens with rapture to the strolling ballad-singer, and wonders at the rude wooden cuts that adorn his ruder compositions. A child looks upon his native village as a town; upon the brook that runs by as a river; and upon the meadows and hills in the neighbourhood as the most spacious and beautiful that can be. But when, after long absence, he returns in his declining years, to visit, once before he die, the dear spot that gave him birth, and those scenes whereof he remembers rather the original charms than the exact proportions; how is he disappointed to find every thing so debased and so diminished! The hills seem to have sunk into the ground, the brook to be dried up, and the village to be forsaken of its people; the parish-church, stripped of all its fancied magnificence, is become low, gloomy, and narrow; and the fields are now only the miniature of what they were. Had he never left this spot, his notions might have remained the same as at first; and had he travelled but a little way from it, they would not perhaps have received any material enlargement.

20 Observation of many things of the same kind a great help to poetical fancy, because

It seems then to be from observation of many things of the same or similar kinds, that we acquire the talent of forming ideas more perfect than the real objects that lie immediately around us: and these ideas we may improve gradually more and more, according to the vivacity of our mind, and extent of our experience, till at last we come to raise them to a degree of perfection superior to any thing to be found in real life. There cannot sure be any mystery in this doctrine; for we think and speak to the same purpose every day. Thus nothing is more common than to say, that such an artist excels all we have ever known in his profession, and yet that we can still conceive a superior performance. A moralist, by bringing together into one view the separate virtues of many persons, is enabled to lay down a system of duty more perfect than any he has ever seen exemplified in human conduct. Whatever be the emotion the poet intends to raise in his reader, whether admiration or terror, joy or sorrow; and whatever be the object he would exhibit, whether Venus or Tisiphone, Achilles or Thersites, a palace or a pile of ruins, a dance or a battle; he generally copies an idea of his own imagination; considering each quality as it is found to exist in several individuals of a species, and thence forming an assemblage more or less perfect in its kind, according to the purpose to which he means to apply it.

21 poetical conceptions must be general,

Hence it would appear, that the ideas of poetry are rather general than singular; rather collected from the examination of a species or class of things, than copied from an individual. And this, according to Aristotle, is in fact the case, at least for the most part; whence that critic determines, that poetry is something more exquisite and more philosophical than history*. The historian may describe Bucephalus, but the poet delineates a war-horse; the former must have seen the animal he speaks of, or received authentic information concerning it, if he mean to describe it historically; for the latter, it is enough that he has seen several animals of that sort. The former tells us, what Achilles actually did and said; the latter, what such a species of human character as that which bears the name of Achilles would probably do or say in certain given circumstances.

* Poetic. § 9.

It is indeed true, that the poet may, and often does, copy after individual objects. Homer, no doubt, took his characters from the life; or at least, in forming them, was careful to follow tradition as far as the nature of his plan would allow. But he probably took the freedom to add or heighten some qualities, and take away others; to make Achilles, for example, stronger, perhaps, and more impetuous, and more eminent for filial affection, and Hector more patriotic and more amiable than he really was. If he had not done this, or something like it, his work would have been rather a history than a poem; would have exhibited men and things as they were, and not as they might have been; and *Achilles* and *Hector* would have been the names of individual and real heroes; whereas, according to Aristotle, they are rather to be considered as two distinct modifications or species of the heroic character. Shakespeare's account of the cliffs of Dover comes so near the truth, that we cannot doubt of its having been written by one who had seen them: but he who takes it for an exact historical description, will be surprised when he comes to the place, and finds those cliffs not half so lofty as the poet had made him believe. An historian would be to blame for such amplification; because, being to describe an individual precipice, he ought to tell us just what it is; which if he did, the description would suit that place, and perhaps no other in the whole world. But the poet means only to give an idea of what such a precipice may be; and therefore his description may perhaps be equally applicable to many such chalky precipices on the sea-shore.

This method of copying after general ideas formed by the artist from observation of many individuals, distinguishes the Italian and all the sublime painters, from the Dutch and their imitators. These give us bare nature, with the imperfections and peculiarities of individual things or persons; but those give nature improved as far as probability and the design of the piece will admit. Teniers and Hogarth draw faces, and figures, and dresses, from real life, and present manners; and therefore their pieces must in some degree lose the effect, and become aukward, when the present fashions become obsolete.——Raphael and Reynolds take their models from general nature; avoiding, as far

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far as possible, (at least in all their great performances), those peculiarities that derive their beauty from mere fashion; and therefore their works must give pleasure, and appear elegant, as long as men are capable of forming general ideas, and of judging from them. The last-mentioned incomparable artist is particularly observant of children, whose looks and attitudes, being less under the controul of art and local manners, are more characteristical of the species than those of men and women. This field of observation has supplied him with many fine figures, particularly that most exquisite one of Comedy, struggling for and winning (for who could resist her!) the affections of Garrick:—a figure which could never have occurred to the imagination of a painter who had confined his views to grown persons looking and moving in all the formality of polite life;—a figure which in all ages and countries would be pronounced natural and engaging;—whereas those human forms that we see every day bowing and courtesying, and strutting, and turning out their toes *secundum artem*, and dressed in ruffles, and wigs, and flounces, and hoop-petticoats, and full-trimmed suits, would appear elegant no further than the present fashions are propagated, and no longer than they remain unaltered.

22 In order to please all ages and countries.

23 The period in the progress of human society to which epic and tragic poets should attend.

There is, in the progress of human society, as well as of human life, a period to which it is of great importance for the higher order of poets to attend, and from which they will do well to take their characters, and manners, and the era of their events; namely, that wherein men are raised above savage life, and considerably improved by arts, government, and conversation; but not advanced so high in the ascent towards politeness, as to have acquired a habit of disguising their thoughts and passions, and of reducing their behaviour to the uniformity of the mode. Such was the period which Homer had the good fortune (as a poet) to live in, and to celebrate. This is the period at which the manners of men are most picturesque, and their adventures most romantic. This is the period when the appetites unperverted by luxury, the powers unnervated by effeminacy, and the thoughts disengaged from artificial restraint, will, in persons of similar dispositions and circumstances, operate in nearly the same way; and when, consequently, the characters of particular men will approach to the nature of poetical or general ideas, and, if well imitated, give pleasure to the whole, or at least to a great majority of mankind. But a character tinctured with the fashions of polite life would not be so generally interesting. Like a human figure adjusted by a modern dancing-master, and dressed by a modern tailor, it may have a good effect in satire, comedy, or farce: but if introduced into the higher poetry, it would be admired by those only who had learned to admire nothing but present fashions, and by them no longer than the present fashions lasted; and to all the rest of the world would appear aukward, unaffecting, and perhaps ridiculous. But Achilles and Sarpedon, Diomede and Hector, Nestor and Ulysses, as drawn by Homer, must in all ages, independently on fashion, command the attention and admiration of mankind. These have the qualities that are universally known to belong to human nature; whereas the modern fine gentleman is distinguished by qualities that belong only to a particular age, society, and corner of the world. We speak not of moral or intellectual virtues, which are objects of admiration to every age; but of those outward accomplishments, and that particular temperature of the passions, which form the most perceptible part of a human character.——As, therefore, the politician, in discussing the rights of mankind, must often allude to an imaginary state of nature; so the poet who intends to raise admiration, pity, terror, and other important emotions, in the generality of mankind, especially in those readers whose minds are most improved, must take his pictures of life and manners, rather from the heroic period we now speak of, than from the ages of refinement; and must therefore (to repeat the maxim of Aristotle) "exhibit things, not as they are, but as they might be."

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Sect. IV. *Of Poetical Characters.*

24 Requisites to the delineation of poetical characters.

Horace seems to think, that a competent knowledge of moral philosophy will fit an author for assigning the suitable qualities and duties to each poetical personage: (*Art. Poet.* v. 309.—316.) The maxim may be true, as far as mere morality is the aim of the poet; but cannot be understood to refer to the delineation of poetical characters in general: for a thorough acquaintance with all the moral philosophy in the world would not have enabled Blackmore to paint such a personage as Homer's Achilles, Shakespeare's Othello, or the Satan of Paradise Lost. To a competency of moral science, there must be added an extensive knowledge of mankind, a warm and elevated imagination, and the greatest sensibility of heart, before a genius can be formed equal to so difficult a task. Horace is indeed so sensible of the danger of introducing a new character in poetry, that he even discourages the attempt, and advises the poet rather to take his persons from the ancient authors, or from tradition: *Ibid.* v. 119.—130.

To conceive the idea of a good man, and to invent and support a great poetical character, are two very different things, however they may seem to have been confounded by some late critics. The first is easy to any person sufficiently instructed in the duties of life: the last is perhaps of all the efforts of human genius the most difficult; so very difficult, that, though attempted by many, Homer, Shakespeare, and Milton, are almost the only authors who have succeeded in it. But characters of perfect virtue are not the most proper for poetry. It seems to be agreed, that the Deity should not be introduced in the machinery of a poetical fable. To ascribe to him words and actions of our own invention, seems very unbecoming; nor can a poetical description, that is known to be, and must of necessity be, infinitely inadequate, ever satisfy the human mind. Poetry, according to the best critics, is an imitation of human action; and therefore poetical characters, though elevated, should still partake of the passions and frailties of humanity. If it were not for the vices of some principal personages, the Iliad would not be either so interesting or so moral: the most moving and most eventful parts of the Æneid are those that describe the effects of unlawful passion:—the most instructive tragedy in the world, we mean Macbeth, is founded in crimes of dreadful enormity:—and if Milton had not taken into his plan the fall of our first parents, as well as their state of innocence, his

25 Which, though elevated should partake of the frailties of humanity;

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his divine poem must have wanted much of its pathos, and could not have been (what it now is) such a treasure of important knowledge, as no other uninspired writer ever comprehended in so small a compass.—— Virtue, like truth, is uniform and unchangeable. We may anticipate the part a good man will act in any given circumstances: and therefore the events that depend on such a man must be less surprising than those which proceed from passion; the vicissitudes whereof it is frequently impossible to foresee. From the violent temper of Achilles, in the Iliad, spring many great incidents; which could not have taken place, if he had been calm and prudent like Ulysses, or pious and patriotic like Eneas: his rejection of Agamemnon's offers, in the ninth book, arises from the violence of his resentment;—his yielding to the request of Patroclus, in the 16th, from the violence of his friendship (if we may so speak) counteracting his resentment; and his restoring to Priam the dead body of Hector, in the 24th, from the violence of his affection to his own aged father, and his regard to the command of Jupiter, counteracting, in some measure, both his sorrow for his friend, and his thirst for vengeance.——Besides, except where there is some degree of vice, it pains us too exquisitely to see misfortune; and therefore poetry would cease to have a pleasurable influence over our tender passions, if it were to exhibit virtuous characters only. And as in life, evil is necessary to our moral probation, and the possibility of error to our intellectual improvement; so bad or mixed characters are useful in poetry, to give to the good such opposition, as puts them upon displaying and exercising their virtue.

26 whilst the personages in whose fate the poet means that we should be interested ou ht to have good and great qualities.

All those personages, however, in whose fortune the poet means that we should be interested, must have agreeable and admirable qualities to recommend them to our regard. And perhaps the greatest difficulty in the art lies in suitably blending those faults which the poet finds it expedient to give to any particular hero, with such moral, intellectual, or corporeal accomplishments, as may engage our esteem, pity, or admiration, without weakening our hatred of vice, or love of virtue. In most of our novels, and in many of our plays, it happens unluckily, that the hero of the piece is so captivating, as to incline us to be indulgent to every part of his character, the bad as well as the good. But a great master knows how to give the proper direction to human sensibility; and, without any perversion of our faculties, or any confusion of right and wrong, to make the same person the object of very different emotions, of pity and hatred, of admiration and horror. Who does not esteem and admire Macbeth for his courage and generosity? who does not pity him when beset with all the terrors of a pregnant imagination, superstitious temper, and awakened conscience? who does not abhor him as a monster of cruelty, treachery, and ingratitude? His good qualities, by drawing us near to him, make us, as it were, eye-witnesses of his crime, and give us a fellow-feeling of his remorse; and therefore, his example cannot fail to have a powerful effect in cherishing our love of virtue, and fortifying our minds against criminal impressions; whereas, had he wanted those good qualities, we should have kept aloof from his concerns, or viewed them with a superficial attention; in which case his example would have had little more weight than that of the robber, of whom we know nothing, but that he was tried, condemned, and executed.—Satan, in Paradise Lost, is a character drawn and supported with the most consummate judgement. The old furies and demons, Hecate, Tisiphone, Alecto, Megara, are objects of unmixed and unmitigated abhorrence; Tityus, Enceladus, and their brethren, are remarkable for nothing but impiety, deformity, and vastness of size; Pluto is, at best, an insipid personage; Mars, a hair-brained ruffian; Tasso's infernal tyrant, an ugly and overgrown monster:—but in the Miltonic Satan, we are forced to admire the majesty of the ruined archangel, at the same time that we detest the unconquerable depravity of the fiend. "But, of all poetical characters, (says the elegant critic from whom we are extracting), the Achilles of Homer (D) seems to me the most exquisite of invention, and the most highly finished. The utility of this character in a moral view is obvious; for it may be considered as the source of all the morality of the Iliad. Had not the generous and violent temper of Achilles determined him to patronize the augur Calchas in defiance of Agamemnon, and afterwards, on being affronted by that vindictive commander, to abandon for a time the common cause of Greece;—the fatal effects of dissension among confederates, and of capricious and tyrannical behaviour in a sovereign, would not have been the leading moral of Homer's poetry; nor could Hector, Sarpedon, Eneas, Ulysses, and the other amiable heroes, have been brought forward to signalize their virtues, and to recommend themselves to the esteem and imitation of mankind.

Beattie's Essays.

27 The excellence of the poetical character of Achilles, and

"They who form their judgement of Achilles from the imperfect sketch given of him by Horace in the *Art of Poetry*, (v. 121, 122.); and consider him only as a hateful composition of anger, revenge, fierceness, obstinacy and pride, can never enter into the views of Homer, nor be suitably affected with his narration. All these vices are no doubt, in some degree, combined in Achilles; but they are tempered with qualities of a different sort, which render him a most interesting character, and of course make the Iliad a most interesting poem. Every reader abhors the faults of this hero: and yet, to an attentive reader of Homer, this hero must be the object of esteem, admiration, and pity; for he has many good as well as bad affections, and is equally violent

(D) "I say the *Achilles of HOMER*. Later authors have degraded the character of this hero, by supposing every part of his body invulnerable except the heel. I know not how often I have heard this urged as one of Homer's absurdities; and indeed the whole Iliad is one continued absurdity, on this supposition. But Homer all along makes his hero equally liable to wounds and death with other men. Nay, to prevent all mistakes in regard to this matter, (if those who cavil at the poet would but read his work), he actually wounds him in the right arm by the lance of Asteropæus, in the battle near the river Scamander." See *Iliad*, xxi. verse 161—168.

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violent in all:—Nor is he poſſeſſed of a ſingle vice or virtue, which the wonderful art of the poet has not made ſubſervient to the deſign of the poem, and to the progreſs and cataſtrophe of the action; ſo that the hero of the Iliad, conſidered as a poetical perſonage, is juſt what he ſhould be, neither greater nor leſs, neither worſe nor better.—He is everywhere diſtinguiſhed by an abhorrence of oppreſſion, by a liberal and elevated mind, by a paſſion for glory, and by a love of truth, freedom, and ſincerity. He is for the moſt part attentive to the duties of religion; and, except to thoſe who have injured him, courteous and kind: he is affectionate to his tutor Phenix; and not only pities the misfortunes of his enemy Priam, but in the moſt ſoothing manner adminiſters to him the beſt conſolation that Homer's poor theology could furniſh. Though no admirer of the cauſe in which his evil deſtiny compels him to engage, he is warmly attached to his native land; and, ardent as he is in vengeance, he is equally ſo in love to his aged father Peleus, and to his friend Patroclus. He is not luxurious like Paris, or clowniſh like Ajax; his accompliſhments are princely, and his amuſements worthy of a hero. Add to this, as an apology for the vehemence of his anger, that the affront he had received was (according to the manners of that age) of the moſt atrocious nature; and not only unprovoked, but ſuch as, on the part of Agamemnon, betrayed a brutal inſenſibility to merit, as well as a proud, ſelfiſh, ungrateful, and tyrannical diſpoſition. And though he is often inexcuſably furious; yet it is but juſtice to remark, that he was not naturally cruel (E); and that his wildeſt outrages were ſuch as in thoſe rude times might be expected from a violent man of invincible ſtrength and valour, when exaſperated by injury, and frantic with ſorrow.—Our hero's claim to the admiration of mankind is indiſputable. Every part of his character is ſublime and aſtoniſhing. In his perſon, he is the ſtrongeſt, the ſwifteſt, the moſt beautiful of men:—this laſt circumſtance, however, occurs not to his own obſervation, being too trivial to attract the notice of ſo great a mind. The Fates had put it in his power, either to return home before the end of the war, or to remain at Troy:—if he choſe the former, he would enjoy tranquillity and happineſs in his own country to a good old age; if the latter, he muſt periſh in the bloom of his youth:—his affection to his father and native country, and his hatred to Agamemnon, ſtrongly urged him to the firſt; but a deſire to avenge the death of his friend determines him to accept the laſt, with all its conſequences. This at once diſplays the greatneſs of his fortitude, the warmth of his friendſhip, and the violence of his ſanguinary paſſions: and it is this that ſo often and ſo powerfully recommends him to the pity, as well as admiration, of the attentive reader."

23 of all Homer's characters.

It is equally a proof of rich invention and exact judgement in Homer, that he mixes ſome good qualities in all his bad characters, and ſome degree of imperfection in almoſt all his good ones.—Agamemnon, notwithſtanding his pride, is an able general, and a valiant man, and highly eſteemed as ſuch by the greater part of the army.—Paris, though effeminate, and vain of his dreſs and perſon, is, however, good-natured, patient of reproof, not deſtitute of courage, and eminently ſkilled in muſic and other fine arts.—Ajax is a huge giant; fearleſs rather from inſenſibility to danger, and confidence in his maſſy arms, than from any nobler principle; boaſtful and rough; regardleſs of the gods, though not downright impious: yet there is in his manner ſomething of frankneſs and blunt ſincerity, which entitle him to a ſhare in our eſteem; and he is ever ready to aſſiſt his countrymen, to whom he renders good ſervice on many a perilous emergency.——The character of Helen, in ſpite of her faults, and of the many calamities whereof ſhe is the guilty cauſe, Homer has found means to recommend to our pity, and almoſt to our love; and this he does, without ſeeking to extenuate the crime of Paris, of which the moſt reſpectable perſonages in the poem are made to ſpeak with becoming abhorrence. She is ſo full of remorſe, ſo ready on every occaſion to condemn her paſt conduct, ſo affectionate to her friends, ſo willing to do juſtice to every body's merit, and withal ſo finely accompliſhed, that ſhe extorts our admiration, as well as that of the Trojan ſenators.——Menelaus, though ſufficiently ſenſible of the injury he had received, is yet a man of moderation, clemency, and good-nature, a valiant ſoldier, and a moſt affectionate brother: but there is a daſh of vanity in his compoſition, and he entertains rather too high an opinion of his own abilities, yet never overlooks nor undervalues the merit of others.—Priam would claim unreſerved eſteem, as well as pity, if it were not for his inexcuſeable weakneſs, in gratifying the humour, and by indulgence abetting the crimes, of the moſt worthleſs of all his children, to the utter ruin of his people, family, and kingdom. Madame Dacier ſuppoſes, that he had loſt his authority, and was obliged to fall in with the politics of the times: but of this there appears no evidence; on the contrary, he and his unworthy favourite Paris ſeem to have been the only perſons of diſtinction in Troy who were averſe to the reſtoring of Helen. Priam's foible (if it can be called by ſo ſoft a name), however faulty, is not uncommon, and has often produced calamity both in private and public life. The Scripture gives a memorable inſtance in the hiſtory of the good old Eli.——Sarpedon comes nearer a perfect character than any other of Homer's heroes; but the part he has to act is ſhort. It is a character which one could hardly have expected in thoſe rude times: a ſovereign prince, who conſiders himſelf as a magiſtrate ſet up by the people for the public good, and therefore bound in honour and gratitude to be himſelf their example, and ſtudy to excel as much in virtue as in rank and authority.——Hector is the favourite of every reader, and with good reaſon. To the trueſt valour he joins the moſt generous patriotiſm. He abominates the crime of Paris: but not being able to prevent the war, he thinks it his duty to defend his country, and his father and ſovereign, to the laſt. He too, as well as Achilles, foreſees his

Beattie, ut ſupra.

(E) See *Iliad* xxi. 100. and xxiv. 485—673.—In the firſt of theſe paſſages, Achilles himſelf declares, that before Patroclus was ſlain, he often ſpared the lives of his enemies, and took pleaſure in doing it. It is ſtrange, as Dr Beattie obſerves, that this ſhould be left out in Pope's Tranſlation.

Of Poetical Characters.

his own death; which heightens our compassion, and raises our idea of his magnanimity. In all the relations of private life, as a son, a father, a husband, a brother, he is amiable in the highest degree; and he is distinguished among all the heroes for tenderness of affection, gentleness of manners, and a pious regard to the duties of religion. One circumstance of his character, strongly expressive of a great and delicate mind, we learn from Helen's lamentation over his dead body, that he was almost the only person in Troy who had always treated her with kindness, and never uttered one reproachful word to give her pain, nor heard others reproach her without blaming them for it. Some tendency to ostentation (which, however, may be pardonable in a commander in chief), and temporary fits of timidity, are the only blemishes discoverable in this hero; whose portrait Homer appears to have drawn with an affectionate and peculiar attention.

By ascribing so many amiable qualities to Hector and some others of the Trojans, the poet interests us in the fate of that people, notwithstanding our being continually kept in mind that they are the injurious party. And by thus blending good and evil, virtue and frailty, in the composition of his characters, he makes them the more conformable to the real appearances of human nature, and more useful as examples for our improvement; and at the same time, without hurting verisimilitude, gives every necessary embellishment to particular parts of his poem, and variety, coherence, and animation, to the whole fable. And it may also be observed, that though several of his characters are complex, not one of them is made up of incompatible parts: all are natural and probable, and such as we think we have met with, or might have met with, in our intercourse with mankind.

From the same extensive views of good and evil, in all their forms and combinations, Homer has been enabled to make each of his characters perfectly distinct in itself, and different from all the rest; insomuch, that before we come to the end of the Iliad, we are as well acquainted with his heroes, as with the faces and tempers of our most familiar friends. Virgil, by confining himself to a few general ideas of fidelity and fortitude, has made his subordinate heroes a very good sort of people; but they are all the same, and we have no clear knowledge of any one of them. Achates is faithful, and Gyas is brave, and Cloanthus is brave; and this is all we can say of the matter. We see these heroes at a distance, and have some notion of their shape and size; but are not near enough to distinguish their features; and every face seems to exhibit the same faint and ambiguous appearance. But of Homer's heroes we know every particular that can be known. We eat, and drink, and talk, and fight, with them: we see them in action and out of it; in the field and in their tents and houses: the very face of the country about Troy we seem to be as well acquainted with as if we had been there. Similar characters there are among these heroes, as there are similar faces in every society; but we never mistake one for another. Nestor and Ulysses are both wise and both eloquent: but the wisdom of the former seems to be the effect of experience; that of the latter of genius: the eloquence of the one is sweet and copious, but not always to the purpose, and apt to degenerate into story-telling; that of the other is close, emphatical, and persuasive, and accompanied with a peculiar modesty and simplicity of manner. Homer's heroes are all valiant; yet each displays a modification of valour peculiar to himself; one is valiant from principle, another from constitution; one is rash, another cautious; one is impetuous and headstrong, another impetuous, but tractable; one is cruel, another merciful; one is insolent and ostentatious, another gentle and unassuming; one is vain of his person, another of his strength, and a third of his family.—It would be tedious to give a complete enumeration. Almost every species of the heroic character is to be found in Homer.

29 Virgil fails in drawing characters.

Of the agents in Paradise Lost, it has been observed *, that "the weakest are the highest and noblest of human beings, the original parents of mankind; with whose actions the elements consented; on whose rectitude or deviation of will depended the state of terrestrial nature, and the condition of all the future inhabitants of the globe. Of the other agents in the poem, the chief are such as it is irreverence to name on slight occasions: the rest are lower powers;

> ——Of which the least could wield
> These elements, and arm him with the force
> Of all their regions:

30 The difficulty of drawing and discriminating the characters in Paradise Lost.

Powers, which only the controul of Omnipotence restrains from laying creation waste, and filling the vast expanse of space with ruin and confusion. To display the motives and actions of beings thus superior, so far as human reason can examine, or human imagination represent them, is the task which Milton undertook and performed. The characters in the Paradise Lost, which admit of examination, are those of angels and of men: of angels good and evil; of man in his innocent and sinful state.

"Among the angels, the virtue of Raphael is mild and placid, of easy condescension, and free communication: that of Michael is regal and lofty, attentive to the dignity of his own nature. Abdiel and Gabriel appear occasionally, and act as every incident requires: the solitary fidelity of Abdiel is very amiably painted.

"Of the evil angels, the characters are more diversified. To Satan such sentiments are given as suit the most exalted and most depraved being. Milton has been censured for the impiety which sometimes breaks from Satan's mouth; for there are thoughts, it is justly remarked, which no observation of character can justify; because no good man would willingly permit them to pass, however transiently, through his mind. This censure has been shown to be groundless by the great critic from whom we quote. To make Satan speak as a rebel, says he, without any such expressions as might taint the reader's imagination, was indeed one of the great difficulties in Milton's undertaking; and I cannot but think that he has extricated himself with great happiness. There is in Satan's speeches little that can give pain to a pious ear. The language of rebellion cannot be the same with that of obedience: the malignity of Satan foams in haughtiness and obstinacy; but his expressions are commonly general, and no otherwise offensive than as they are wicked.—The other chiefs of the celestial rebellion are very judiciously discriminated; and the ferocious character of Moloch appears, both in the battle and in the council, with exact consistency.

31 Milton's success in this part of his undertaking.

* Johnson's Life of Milton.

"To

Of Poetical Arrangement, &c.

"To Adam and to Eve are given, during their innocence, ſuch ſentiments as innocence can generate and utter. Their love is pure benevolence and mutual veneration; their repaſts are without luxury, and their diligence without toil. Their addreſſes to their Maker have little more than the voice of admiration and gratitude: fruition left them nothing to aſk, and innocence left them nothing to fear. But with guilt enter diſtruſt and diſcord, mutual accuſation and ſtubborn ſelf-defence: they regard each other with alienated minds, and dread their Creator as the avenger of their tranſgreſſion; at laſt, they ſeek ſhelter in his mercy, ſoften to repentance, and melt in ſupplication. Both before and after the fall, the different ſentiments ariſing from difference of ſex are traced out with inimitable delicacy and philoſophical propriety. Adam has always that preeminence in dignity, and Eve in lovelineſs, which we ſhould naturally look for in the father and mother of mankind."

From what has been ſaid, it ſeems abundantly evident, —That the end of poetry is to pleaſe; and therefore that the moſt perfect poetry muſt be the moſt pleaſing; —that what is unnatural cannot give pleaſure; and therefore that poetry muſt be according to nature:— that it muſt be either according to real nature, or according to nature ſomewhat different from the reality; —that, if according to real nature, it would give no greater pleaſure than hiſtory, which is a tranſcript of real nature;—that greater pleaſure is, however, to be expected from it, becauſe we grant it ſuperior indulgence, in regard to fiction, and the choice of words;— and, conſequently, that poetry muſt be, not according to real nature, but according to nature improved to that degree which is conſiſtent with probability and ſuitable to the poet's purpoſe.——And hence it is that we call poetry, *An imitation of nature.*—For that which is properly termed *imitation* has always in it ſomething which is not in the original. If the prototype and tranſcript be exactly alike; if there be nothing in the one which is not in the other; we may call the latter a *repreſentation*, a *copy*, a *draught*, or a *picture*, of the former; but we never call it an *imitation*.

32
Poetry according to nature improved to that degree which is conſiſtent with probability.

Sect. V. *Of Arrangement, Unity, Digreſſions.—Further remarks on Nature in Poetry.*

33
How a poem ought to begin.

I. The origin of nations, and the beginnings of great events, are little known, and ſeldom intereſting; whence the firſt part of every hiſtory, compared with the ſequel, is ſomewhat dry and tedious. But a poet muſt, even in the beginning of his work, intereſt the readers, and raiſe high expectation; not by an affected pomp of ſtyle, far leſs by ample promiſes or bold profeſſions; but by ſetting immediately before them ſome incident, ſtriking enough to raiſe curioſity, in regard both to its cauſes and to its conſequences. He muſt therefore take up his ſtory, not at the beginning, but in the middle; or rather, to prevent the work from being too long, as near the end as poſſible; and afterwards take ſome proper opportunity to inform us of the preceding events, in the way of narrative, or by converſation of the perſons introduced, or by ſhort and natural digreſſions.

The action of both the *Iliad* and *Odyſſey* begins about ſix weeks before its concluſion; although the principal events of the war of Troy are to be found in the former; and the adventures of a ten years voyage, followed by the ſuppreſſion of a dangerous domeſtic enemy, in the latter. One of the firſt things mentioned by Homer in the Iliad, is a plague, which Apollo in anger ſent into the Grecian army commanded by Agamemnon and now encamped before Troy. Who this Agamemnon was, and who the Grecians were; for what reaſon they had come hither; how long the ſiege had laſted; what memorable actions had been already performed; and in what condition both parties now were:—all this, and much more, we ſoon learn from occaſional hints and converſations interſperſed through the poem.

In the *Æneid*, which, though it comprehends the tranſactions of ſeven years, opens within a few months of the concluding event, we are firſt preſented with a view of the Trojan fleet at ſea, and no leſs a perſon than Juno intereſting herſelf to raiſe a ſtorm for their deſtruction. This excites a curioſity to know ſomething further: who theſe Trojans were, whence they had come, and whither they were bound; why they had left their own country, and what had befallen them ſince they left it. On all theſe points, the poet, without quitting the track of his narrative, ſoon gives the fulleſt information: The ſtorm riſes; the Trojans are driven to Africa, and hoſpitably received by the queen of the country; at whoſe deſire their commander relates his adventures.

The action of *Paradiſe Loſt* commences not many days before Adam and Eve are expelled from the garden of Eden, which is the concluding event. This poem, as its plan is incomparably more ſublime and more important than that of either the Iliad or Æneid, opens with a far more intereſting ſcene: a multitude of angels and archangels ſhut up in a region of torment and darkneſs, and rolling on a lake of unquenchable fire. Who theſe angels are, and what brought them into this miſerable condition, we naturally wiſh to know; and the poet in due time informs us; partly from the converſation of the fiends themſelves; and more particularly by the mouth of a happy ſpirit, ſent from heaven to caution the father and mother of mankind againſt temptation, and confirm their good reſolutions by unfolding the dreadful effects of impiety and diſobedience.

Beattie, ut ſupra.

34
The advantage of the poetical arrangement.

This poetical arrangement of events, ſo different from the hiſtorical, has other advantages beſides thoſe ariſing from brevity and compactneſs of detail: it is obviouſly more affecting to the fancy, and more alarming to the paſſions; and, being more ſuitable to the order and the manner in which the actions of other men ſtrike our ſenſes, is a more exact imitation of human affairs. I hear a ſudden noiſe in the ſtreet, and run to ſee what is the matter. An inſurrection has happened, a great multitude is brought together, and ſomething very important is going forward. The ſcene before me is the firſt thing that engages my attention; and is in itſelf ſo intereſting, that for a moment or two I look at it in ſilence and wonder. By and by, when I get time for reflection, I begin to inquire into the cauſe of all this tumult, and what it is the people would be at; and one who is better informed than I, explains the affair from the beginning; or perhaps I make this out for myſelf, from the words and actions of the perſons principally concerned. This is a ſort of picture of poetical arrangement, both in epic and dramatic compoſition; and this plan

Of Poetical Arrangement, &c. plan has been followed in narrative odes and ballads both ancient and modern.—The historian pursues a different method. He begins perhaps with an account of the manners of a certain age, and of the political constitution of a certain country; then introduces a particular person, gives the story of his birth, connections, private character, pursuits, disappointments, and of the events that promoted his views, and brought him acquainted with other turbulent spirits like himself; and so proceeds, unfolding, according to the order of time, the causes, principles, and progress of the conspiracy, if that be the subject which he undertakes to illustrate. It cannot be denied, that this latter method is more favourable to calm information: but the former, compared with it, will be found to have all the advantages already specified, and to be more effectually productive of that mental pleasure which depends on the passions and imagination.

35 Unity of design necessary to the higher poetry.

II. If a work have no determinate end, it has no meaning; and if it have many ends, it will distract by its multiplicity. Unity of design, therefore, belongs in some measure to all compositions, whether in verse or prose. But to some it is more essential than to others; and to none so much as in the higher poetry. In certain kinds of history, there is unity sufficient if all the events recorded be referred to one person; in others, if to one period of time, or to one people, or even to the inhabitants of one and the same planet. But it is not enough that the subject of a poetical fable be the exploits of one person; for these may be of various and even of opposite sorts and tendencies, and take up longer time than the nature of poetry can admit:—far less can a regular poem comprehend the affairs of one period or of one people:—it must be limited to one great action or event, to the illustration of which all the subordinate events must contribute; and these must be so connected with one another, as well as with the poet's general purpose, that one cannot be changed, transposed, or taken away, without affecting the consistence and stability of the whole *. In itself an incident may be interesting, a character well drawn, a description beautiful; and yet, if it disfigure the general plan, or if it obstruct or encumber the main action, instead of helping it forward, a correct artist would consider it but as a gaudy superfluity or splendid deformity; like a piece of scarlet cloth sewed upon a garment of a different colour †. Not that all the parts of the fable either are, or can be, equally essential. Many descriptions and thoughts, of little consequence to the plan, may be admitted for the sake of variety; and the poet may, as well as the historian and philosopher, drop his subject for a time, in order to take up an affecting or instructive digression.

* *Arist. Poet.* § 8.

† *Hor. Ar. Poet.* v. 15. *&c.*

36 The propriety of digressions and episodes depends upon

III. The doctrine of poetical digressions and episodes has been largely treated by the critics. We shall here only remark, that, in estimating their propriety, three things are to be attended to:—their connection with the fable or subject; their own peculiar excellence; and their subserviency to the poet's design.

37 their connection with the subject of the poem.

(1.) Those digressions that both arise from and terminate in the subject, like the episode of the angel Raphael in Paradise Lost, and the transition to the death of Cæsar and the civil wars in the first book of the Georgic, are the most artful, and if suitably executed claim the highest praise:—those that arise from, but do not terminate in, the subject, are perhaps second in the order of merit; like the story of Dido in the Æneid, and the encomium on a country life in the second book of the Georgic: those come next that terminate in, but do not rise from, the fable; of which there are several in the third book of the Æneid, and in the Odyssey:—and those that neither terminate in the fable nor rise from it are the least artful; and if they be long, cannot escape censure, unless their beauty be very great.

38 Their own peculiar excellence, and

But (2.) we are willing to excuse a beautiful episode at whatever expence to the subject it may be introduced. They who can blame Virgil for obtruding upon them the charming tale of Orpheus and Euridice in the fourth Georgic, or Milton for the apostrophe to light in the beginning of his third book, ought to forfeit all title to the perusal of good poetry; for of such divine strains one would rather be the author than of all the books of criticism in the world. Yet still it is better that an episode possess the beauty of connection, together with its own intrinsic elegance, than this without the other.

39 their subserviency to the poet's design.

Moreover, in judging of the propriety of episodes and other similar contrivances, it may be expedient to attend (3.) to the design of the poet, as distinguished from the fable or subject of the poem. The great design, for example, of Virgil, was to interest his countrymen in a poem written with a view to reconcile them to the person and government of Augustus. Whatever, therefore, in the poem tends to promote this design, even though it should in some degree hurt the contexture of the fable, is really a proof of the poet's judgement; and may be not only allowed, but applauded.—The progress of the action of the Æneid may seem to be too long obstructed in one place by the story of Dido, which, though it rises from the preceding part of the poem, has no influence upon the sequel; and, in another, by the episode of Cacus, which, without injury to the fable, might have been omitted altogether. Yet these episodes, interesting as they are to us and all mankind because of the transcendant merit of the poetry, must have been still more interesting to the Romans because of their connection with the Roman affairs; for the one accounts poetically for their wars with Carthage; and the other not only explains some of their religious ceremonies, but also gives a most charming rural picture of those hills and valleys in the neighbourhood of the Tiber, on which, in after times, their majestic city was fated to stand.—And if we consider, that the design of Homer's Iliad was not only to show the fatal effects of dissension among confederates, but also to immortalize his country, and celebrate the most distinguished families in it, we shall be inclined to think more favourably than critics generally do of some of his long speeches and digressions; which, though to us they may seem trivial, must have been very interesting to his countrymen on account of the genealogies and private history recorded in them.—Shakespeare's historical plays, considered as dramatic fables, and tried by the laws of tragedy and comedy, appear very rude compositions; but if we attend to the poet's design (as the elegant critic ‡ has with equal truth and beauty explained it), we shall be forced to admire his judgement in the general conduct of those pieces, as well as unequalled success in the execution of particular parts.

‡ *Essays on the writings and genius of Shakespeare*, p. 55.

There is yet another point of view in which these digressions may be considered. If they tend to elucidate any important character, or to introduce any interesting event not otherwise within the compass of the poem, or to to give an amiable diſplay of any particular virtue, they may be intitled, not to our pardon only, but even to our admiration, however looſely they may hang upon the fable. All theſe three ends are effected by that moſt beautiful epiſode of Hector and Andromache in the ſixth book of the Iliad; and the two laſt, by the no leſs beautiful one of Euryalus and Niſus in the ninth book of the Æneid.

IV. And now, from the poſition formerly eſtabliſhed, that the end of this divine art is to give pleaſure, it has been endeavoured to prove, that, whether in diſplaying the appearances of the material univerſe, or in imitating the workings of the human mind, and the varieties of human character, or in arranging and combining into one whole the ſeveral incidents and parts whereof his fable conſiſts,—the aim of the poet muſt be to copy nature, not as it is, but in that ſtate of perfection in which, conſiſtently with the particular genius of the work, and the laws of veriſimilitude, it may be ſuppoſed to be.

Such, in general, is the nature of that poetry which is intended to raiſe admiration, pity, and other ſerious emotions. But in this art, as in all others, there are different degrees of excellence; and we have hitherto directed our view chiefly to the higheſt. All ſerious poets are not equally ſolicitous to improve nature. Euripides is ſaid to have repreſented men as they were; Sophocles, more poetically, as they ſhould or might be ||. Theocritus in his Idyls, and Spenſer in his Shepherd's Calendar, give us language and ſentiments more nearly approaching thoſe of the *Rus verum et barbarum* §, than what we meet with in the Paſtorals of Virgil and Pope. In the hiſtorical drama, human characters and events muſt be according to hiſtorical truth, or at leaſt not ſo remote from it as to lead into any important miſapprehenſion of fact. And in the hiſtorical epic poem, ſuch as the Pharſalia of Lucan, and the Campaign of Addiſon, the hiſtorical arrangement is preferred to the poetical, as being nearer the truth. Yet nature is a little improved even in theſe poems. The perſons in Shakeſpeare's hiſtorical plays, and the heroes of the Pharſalia, talk in verſe, and ſuitably to their characters, and with a readineſs, beauty, and harmony of expreſſion, not to be met with in real life, nor even in hiſtory: ſpeeches are invented, and, to heighten the deſcription, circumſtances added, with great latitude: real events are rendered more compact and more ſtrictly dependent upon one another; and fictitious ones brought in, to elucidate human characters and diverſify the narration.

|| *Ariſt. Poet.*

§ *Martial.*

40 Nature always to be improved by the poet, though

The more poetry improves nature, by copying after general ideas collected from extenſive obſervation, the more it partakes (according to Ariſtotle) of the nature of philoſophy; the greater ſtretch of fancy and of obſervation it requires in the artiſt, the better chance it has to be univerſally agreeable.

41 when poetry falls ſhort of this perfection it may have great merit in other reſpects.

Yet poetry, when it falls ſhort of this perfection, may have great merit as an inſtrument of both inſtruction and pleaſure. To moſt men, ſimple unadorned nature is, at certain times, and in certain compoſitions, more agreeable than the moſt elaborate improvements of art; as a plain ſhort period, without modulation, gives a pleaſing variety to a diſcourſe. Many ſuch portraits of ſimple nature there are in the ſubordinate parts both of Homer's and of Virgil's poetry: and an excellent effect they have in giving probability to the fiction, as well as in gratifying the reader's fancy with images diſtinct and lively, and eaſily comprehended. The hiſtorical plays of Shakeſpeare raiſe not our pity and terror to ſuch a height as Lear, Macbeth, or Othello; but they intereſt and inſtruct us greatly notwithſtanding. The rudeſt of the eclogues of Theocritus, or even of Spenſer, have by ſome authors been extolled above thoſe of Virgil, becauſe more like real life. Nay, Corneille is known to have preferred the Pharſalia to the Æneid, perhaps from its being nearer the truth, or perhaps from the ſublime ſentiments of ſtoical morality ſo forcibly and ſo oſtentatiouſly diſplayed in it.

Poets may refine upon nature too much as well as too little; for affectation and ruſticity are equally remote from true elegance. The ſtyle and ſentiments of comedy ſhould no doubt be more correct and more pointed than thoſe of the moſt polite converſation: but to make every footman a wit, and every gentleman and lady an epigrammatiſt, as Congreve has done, is an exceſſive and faulty refinement. The proper medium has been hit by Menander and Terence, by Shakeſpeare in his happier ſcenes, and by Garrick, Cumberland, and ſome others of late renown. To deſcribe the paſſion of love with as little delicacy as ſome men ſpeak of it would be unpardonable; but to transform it into mere Platonic adoration is to run into another extreme, leſs criminal indeed, but too remote from univerſal truth to be univerſally intereſting. To the former extreme Ovid inclines, and Petrarch and his imitators to the latter. Virgil has happily avoided both: but Milton has painted this paſſion as diſtinct from all others, with ſuch peculiar truth and beauty, that we cannot think Voltaire's encomium too high, when he ſays, that love in all other poetry ſeems a weakneſs, but in Paradiſe Loſt a virtue. There are many good ſtrokes of nature in Ramſay's Gentle Shepherd; but the author's paſſion for the *rus verum* betrays him into ſome indelicacies: a cenſure that falls with greater weight upon Theocritus, who is often abſolutely indecent. The Italian paſtoral of Taſſo and Guarini, and the French of Fontenelle, run into the oppoſite extreme (though in ſome parts beautifully ſimple), and diſplay a ſyſtem of rural manners ſo quaint and affected as to outrage all probability. In fine, though mediocrity of execution in poetry be allowed to deſerve the doom pronounced upon it by Horace; yet it is true, notwithſtanding, that in this art, as in many other good things, the point of excellence lies in a middle between two extremes; and has been reached by thoſe only who ſought to improve nature as far as the genius of their work would permit, keeping at an equal diſtance from ruſticity on the one hand, and affected elegance on the other.

Sect. VI. *Of Poetical Language.*

42 Words in poetry to be choſen for their ſenſe and for their ſound.

Words in poetry are choſen, firſt, for their *ſenſe*; and, ſecondly, for their *ſound*. That the firſt of theſe grounds of choice is the more excellent nobody can deny. He who in literary matters prefers ſound to ſenſe is a fool. Yet ſound is to be attended to even in proſe, and in verſe demands particular attention. We ſhall conſider poetical language, firſt, as SIGNIFICANT; and, ſecondly, as SUSCEPTIBLE OF HARMONY.

§ 1.

Of Poetical Language.

§ 1. *Of Poetical Language considered as SIGNIFICANT.*

43 The language of poetry an imitation of the language of nature,

If, as it has been endeavoured to prove, poetry be imitative of nature, poetical fictions of real events, poetical images of real appearances in the visible creation, and poetical personages of real human characters; it would seem to follow, that the *language of poetry* must be an imitation of the *language of nature.*

According to Dr Beattie *, that language is natural which is suited to the speaker's condition, character, and circumstances. And as, for the most part, the images and sentiments of serious poetry are copied from the images and sentiments, not of real, but of improved, nature; so the language of serious poetry must (as hinted already be a transcript, not of the real language of nature, which is often dissonant and rude, but of natural language improved as far as may be consistent with probability, and with the supposed character of the speaker. If this be not the case, if the language of poetry be such only as we hear in conversation or read in history, it will, instead of delight, bring disappointment: because it will fall short of what we expect from an art which is recommended rather by its pleasurable qualities than by its intrinsic utility; and to which, in order to render it pleasing, we grant higher privileges than to any other kind of literary composition, or any other mode of human language.

* *Essays*, Part ii. chap. 1.

44 improved as far as may be consistent with probability, &c.

The next inquiry must therefore be, "What are those improvements that peculiarly belong to the language of poetry?" And these may be comprehended under two heads; *poetical words*, and *tropes and figures.*

Art. I. Of Poetical Words.

45 All languages have words peculiar to poetry.

One mode of improvement peculiar to poetical diction results from the use of those words and phrases which, because they rarely occur in prose, and frequently in verse, are by the grammarian and lexicographer termed *poetical*. In these some languages abound more than others; but no language perhaps is altogether without them, and perhaps no language can be so in which any number of good poems have been written: for poetry is better remembered than prose, especially by poetical authors, who will always be apt to imitate the phraseology of those they have been accustomed to read and admire; and thus, in the works of poets down through successive generations, certain phrases may have been conveyed, which, though originally perhaps in common use, are now confined to poetical composition. Prose writers are not so apt to imitate one another, at least in words and phrases, both because they do not so well remember one another's phraseology, and also because their language is less artificial, and must not, if they would make it easy and flowing (without which it cannot be elegant), depart essentially from the style of correct conversation. Poets, too, on account of the greater difficulty of their numbers, have, both in the choice and in the arrangement of words, a better claim to indulgence, and stand more in need of a discretionary power.

The language of Homer differs materially from what was written and spoken in Greece in the days of Socrates. It differs in the mode of inflection, it differs in the syntax, it differs even in the words: so that one might read Homer with ease who could not read Xenophon; or Xenophon, without being able to read Homer. Yet we cannot believe that Homer, or the first Greek poet who wrote in his style, would make choice of a dialect quite different from what was intelligible in his own time: for poets have in all ages written with a view to be read, and to be read with pleasure; which they could not be if their diction were hard to be understood. It is more reasonable to suppose that the language of Homer is according to some ancient dialect, which, though not perhaps in familiar use among the Greeks at the time he wrote, was however intelligible. From the Homeric to the Socratic age, a period had elapsed of no less than 400 years; during which the style both of discourse and of writing must have undergone great alterations. Yet the Iliad continued the standard of heroic poetry, and was considered as the very perfection of poetical language; notwithstanding that some words in it were become so antiquated, or so ambiguous, that Aristotle himself seems to have been somewhat doubtful in regard to their meaning †. And if Chaucer's merit as a poet had been as great as Homer's, and the English tongue under Edward III. as perfect as the Greek was in the second century after the Trojan war, the style of Chaucer would probably have been our model for poetical diction at this day; even as Petrarch, his contemporary, is still imitated by the best poets of Italy.

† *Poetic.* cap. 25.

The rudeness of the style of Ennius has been imputed by the old critics to his having copied too closely the dialect of common life. But this appears to be a mistake. For if we compare the fragments of that author with the comedies of Plautus, who flourished in the same age, and whose language was certainly copied from that of common life, we shall be struck with an air of antiquity in the former that is not in the latter. Ennius, no doubt, like most other sublime poets, affected something of the antique in his expression: and many of his words and phrases, not adopted by any prose-writer now extant, are to be found in Lucretius and Virgil, and were by them transmitted to succeeding poets. These form part of the Roman poetical dialect; which appears from the writings of Virgil, where we have it in perfection, to have been very copious. The style of this charming poet is indeed so different from prose, and is altogether so peculiar, that it is perhaps impossible to analyse it on the common principles of Latin grammar. And yet no author can be more perspicuous or more expressive; notwithstanding the frequency of Grecism in his syntax, and his love of old words, which he, in the judgement of Quintilian, knew better than any other man how to improve into decoration ||.

46 The poetical dialect different from that of prose.

|| *Instit.* viii. 3. § 3.

The poetical dialect of modern Italy is so different from the prosaic, that persons who can read the historians, and even speak with tolerable fluency the language of that country, may yet find it difficult to construe a page of Petrarch or Tasso. Yet it is not probable, that Petrarch, whose works are a standard of the Italian poetical diction §, made any material innovations in his native tongue. It is rather probable that he wrote it nearly as it was spoken in his time, that is, in the 14th century; omitting only harsh combinations, and taking that liberty which Homer probably, and Virgil certainly, took before him, of reviving such old, but not obsolete expressions, as seemed peculiarly significant and melodious; and polishing his style to that degree of elegance which human speech, without becoming

§ *Vicende della litteratura del Denina*, cap. 4.

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ming unnatural, may admit of, and which the genius of poetry, as an art subservient to pleasure, may be thought to require.

The French poetry in general is distinguished from prose rather by the rhime and the measure, than by any old or uncommon phraseology. Yet the French, on certain subjects, imitate the style of their old poets, of Marot in particular; and may therefore be said to have something of a poetical dialect, though far less extensive than the Italian, or even than the English. And it may be presumed, that in future ages they will have more of this dialect than they have at present. This may be inferred from the very uncommon merit of some of their late poets, particularly Boileau and La Fontaine, who, in their respective departments, will continue to be imitated, when the present modes of French prose are greatly changed: an event that, for all the pains they take to preserve their language, must inevitably happen, and whereof there are not wanting some presages already.

The English poetical dialect is not characterised by any peculiarities of inflection, nor by any great latitude in the use of foreign idioms. More copious it is, however, than one would at first imagine; as may appear from the following specimen and observations.

47 Phrases in English poetry not usual in prose

(1.) A few Greek and Latin idioms are common in English poetry, which are seldom or never to be met with in prose. QUENCHED OF HOPE. Shakespeare.—SHORN OF HIS BEAMS. Milton.—*Created thing* NOR VALUED HE NOR SHUN'D. Milton.—*'Tis thus we riot, while* WHO SOW IT STARVE. Pope.—*This day* BE BREAD AND PEACE MY LOT. Pope.—INTO WHAT PIT THOU SEE'ST FROM WHAT HEIGHT FALLEN. Milton. *He deceived the mother of mankind.* WHAT TIME HIS PRIDE HAD CAST HIM *out of heaven.* Milton.—Some of these, with others to be found in Milton, seem to have been adopted for the sake of brevity, which in the poetical tongue is indispensable. For the same reason, perhaps the articles *a* and *the* are sometimes omitted by our poets, though less frequently in serious than burlesque composition.——In English, the adjective generally goes before the substantive, the nominative before the verb, and the active verb before (what we call) the accusative. Exceptions, however, to this rule, are not uncommon even in prose. But in poetry they are more frequent. *Their homely joys, and* DESTINY OBSCURE. *Now fades the glimmering landscape on the sight; and all the air a solemn stillness holds.* In general, that versification may be less difficult, and the cadence more uniformly pleasing; and sometimes, too, in order to give energy to expression, or vivacity to an image,—the English poet is permitted to take much greater liberties than the prose-writer, in arranging his words, and modulating his lines and periods. Examples may be seen in every page of Paradise Lost.

(2.) Some of our poetical words take an additional syllable, that they may suit the verse the better; as, *dispart, distain, disport, affright, enchain*, for part, stain, sport, fright, chain. Others seem to be nothing else than common words made shorter, for the convenience of the versifier. Such are, *auxiliar, sublunar, trump, vale, part, clime, submiss, frolic, plain, drear, dread, helm, morn, mead, eve* and *even, gan, illume* and *illumine, ope, hoar, bide, swage, scape;* for auxiliary, sublunary, trumpet, valley, depart, climate, submissive, frolicsome, complain, dreary, dreadful, helmet, morning, meadow, evening, began or began to, illuminate, open, hoary, abide, assuage, escape.——Of some of these the short form is the more ancient. In Scotland, *even, morn, bide, swage*, are still in vulgar use; but *morn*, except when contradistinguished to *even*, is synonymous, not with *morning* (as in the English poetical dialect), but with *morrow*. The Latin poets, in a way somewhat similar, and perhaps for a similar reason, shortened *fundamentum, tutamentum, munimentum*, &c. into fundamen, tutamen, munimen.

(3.) Of the following words, which are now almost peculiar to poetry, the greater part are ancient, and were once no doubt in common use in England, as many of them still are in Scotland. *Afield, amain, annoy* (a noun), *anon, aye* (ever), *behest, blithe, brand* (sword), *bridal, carol, dame* (lady), *featly, fell* (an adjective), *gaude, gore, host* (army), *lambkin, late* (of late), *lay* (poem), *lea, glade, gleam, hurl, lore, meed, orisons, plod* (to travel laboriously), *ringlet, rue* (a verb) *ruth, ruthless, sojourn* (a noun), *smite, speed* (an active verb), *save* (except), *spray* (twig), *steed, strain* (song), *strand, swain, thrall, thrill, trail* (a verb), *troll, wail, welter, warble, wayward, wöo, the while* (in the mean time), *yon, of yore.*

(4.) These that follow are also poetical; but, so far as appears, were never in common use. *Appal, arrowy, attune, battailous, breezy, car* (chariot), *clarion, cates, courser, darkling, flicker, floweret, emblaze, gairish, circlet, impearl, nightly, noiseless, pinion* (wing), *shadowy, slumberous, streamy, troublous, wilder* (a verb), *shrill* (a verb), *shook* (shaken), *madding, viewless.*—The following, too, derived from the Greek and Latin, seem peculiar to poetry. *Clang, clangor, choral, bland, boreal, dire, ensanguined, ire, ireful, lave* (to wash), *nymph*, (lady, girl), *orient, panoply, philomel, infuriate, jocund, radiant, rapt, redolent, refulgent, verdant, vernal, zephyr, zone* (girdle), *sylvan, suffuse.*

(5.) In most languages, the rapidity of pronunciation abbreviates some of the commonest words, or even joins two, or perhaps more, of them, into one; and some of those abbreviated forms find admission into writing. The English language was quite disfigured by them in the end of the last century; but Swift, by his satire and example, brought them into disrepute: and, though some of them be retained in conversation, as *don't, shan't, can't*, they are now avoided in solemn style; and by elegant writers in general, except where the colloquial dialect is imitated, as in comedy. *'Tis* and *'twas*, since the time of Shaftesbury, seem to have been daily losing credit, at least in prose; but still have a place in poetry, perhaps because they contribute to conciseness. *'Twas on a lofty vase's side.* Gray.—*'Tis true, 'tis certain, man, though dead, retains part of himself.* Pope. In verse too, *over* may be shortened into *o'er*, (which is the Scotch, and probably was the old English, pronunciation); *never* into *ne'er;* and from *the* and *to*, when they go before a word beginning with a vowel, the final letter is sometimes cut off. *O'er hills, o'er dales, o'er crags, o'er rocks they go.* Pope.—*Where'er she turns, the Graces homage pay. And all that beauty, all that wealth e'er gave. Rich with the spoils of time did ne'er unroll.* Gray.—*T'alarm th' eternal midnight of the grave.*——These abbreviations are now peculiar to the poetical tongue, but not necessary to it. They sometimes

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ſometimes promote brevity, and render verſification leſs difficult.

(6.) Thoſe words which are commonly called *compound epithets*, as *roſy-finger'd*, *roſy boſom'd*, *many-twinkling*, *many-ſounding*, *moſs-grown*, *bright-eyed*, *ſtraw-built*, *ſpirit-ſtirring*, *incenſe-breathing*, *heaven taught*, *love-whiſpering*, *lute-reſounding*, are alſo to be conſidered as part of our poetical dialect. It is true, we have compounded adjectives in familiar uſe, as *high-ſeaſoned*, *well-natured*, *ill-bred*, and innumerable others. But we ſpeak of thoſe that are leſs common, that ſeldom occur except in poetry, and of which in proſe the uſe would appear affected. And that they ſometimes promote brevity and vivacity of expreſſion, cannot be denied. But as they give, when too frequent, a ſtiff and finical air to a performance; as they are not always explicit in the ſenſe, nor agreeable in the ſound; as they are apt to produce a confuſion, or too great a multiplicity, of images; as they tend to disfigure the language, and furniſh a pretext for endleſs innovation; they ought to be uſed ſparingly; and thoſe only uſed which the practice of popular authors has rendered familiar to the ear, and which are in themſelves peculiarly emphatical and harmonious.

48 to be uſed ſparingly:

(7.) In the transformation of nouns into verbs and participles, our poetical dialect admits of greater latitude than proſe. Hymn, pillow, curtain, ſtory, pillar, picture, peal, ſurge, cavern, honey, career, cincture, boſom, ſphere, are common nouns; but *to hymn*, *to pillow*, *curtained*, *pillared*, *pictured*, *pealing*, *ſurging*, *cavern'd*, *honied*, *careering*, *cinctured*, *boſomed*, *ſphered*, would appear affected in proſe, and yet in verſe they are warranted by great authorities, though it muſt be confeſſed that they are cenſured by an able critic*; who had ſtudied the Engliſh language, both poetical and proſaic, with wonderful diligence.

* *Johnſon.*

Some late poets, particularly the imitators of Spenſer, have introduced a great variety of uncommon words, as certes, eftſoons, ne, whilom, tranſmew, moil, ſone, loſel, albe, hight, dight, pight, thews, couthful, affot, muchel, wend, arrear, &c. Theſe were once poetical words, no doubt; but they are now obſolete, and to many readers unintelligible. No man of the preſent age, however converſant in this dialect, would naturally expreſs himſelf in it on any intereſting emergence; or, ſuppoſing this natural to the antiquarian, it would never appear ſo to the common hearer or reader. A mixture of theſe words, therefore, muſt ruin the pathos of modern language: and as they are not familiar to our ear, and plainly appear to be ſought after and affected, will generally give a ſtiffneſs to modern verſification. Yet in ſubjects approaching to the ludicrous they may have a good effect; as in the *Schoolmiſtreſs* of Shenſtone, Parnel's Fairy-tale, Thomſon's Caſtle of Indolence, and Pope's lines in the Dunciad upon Wormius. But this effect will be moſt pleaſing to thoſe who have leaſt occaſion to recur to the gloſſary.

Indeed, it is not always eaſy to fix the boundary between poetical and obſolete expreſſions. To many readers, *lore*, *meed*, *beheſt*, *blithe*, *gaude*, *ſpray*, *thrall*, may already appear antiquated; and to ſome the ſtyle of Spenſer, or even of Chaucer, may be as intelligible as that of Dryden. This however we may venture to affirm, that a word, which the majority of readers cannot underſtand without a gloſſary, may with reaſon be conſidered as obſolete; and ought not to be uſed in modern compoſition, unleſs revived, and recommended to the public ear, by ſome very eminent writer. There are but few words in Milton, as *nathleſs*, *tine*, *frore*, *boſky*, &c.; there are but one or two in Dryden, as *falſify* (F); and in Pope, there are none at all, which every reader of our poetry may not be ſuppoſed to underſtand: whereas in Shakeſpeare, there are many, and in Spenſer many more, for which one who knows Engliſh very well may be obliged to conſult the dictionary. The practice of Milton, Dryden, or Pope, may therefore, in almoſt all caſes, be admitted as good authority for the uſe of a poetical word. And in them, all the words above enumerated, as poetical, and in preſent uſe, may actually be found. And of ſuch poets as may chooſe to obſerve this rule, it will not be ſaid, either that they reject the judgment of Quintilian, who recommends the neweſt of the old words, and the oldeſt of the new, or that they are inattentive to Pope's precept;

Be not the firſt by whom the new are tried,
Nor yet the laſt to lay the old aſide.

Eſſ. on Crit. v. 335.

We muſt not ſuppoſe that theſe poetical words never occur at all except in poetry. Even from converſation they are not excluded: and the ancient critics allow, that they may be admitted into proſe, where they occaſionally confer dignity upon a ſublime ſubject, or heighten the ludicrous qualities of a mean one. But it is in poetry only where the frequent uſe of them does not favour of affectation.

Nor muſt we ſuppoſe them eſſential to this art. Many paſſages there are of exquiſite poetry, wherein not a ſingle phraſe occurs that might not be uſed in proſe. In fact, the influence of theſe words in adorning Engliſh verſe is not very extenſive. Some influence however they have. They ſerve to render the poetical ſtyle, firſt, more melodious; and, ſecondly, more ſolemn.

49 In which caſe they may render the poetical ſtyle more melodious

Firſt, They render the poetical ſtyle more melodious, and more eaſily reducible into meaſure. Words of unwieldy ſize, or difficult pronunciation, are never uſed by correct poets, where they can be avoided: unleſs in their ſound they have ſomething imitative of the ſenſe. Homer's poetical inflections contribute wonderfully to the ſweetneſs of his numbers: and if the reader is pleaſed to look back to the ſpecimen above given of the Engliſh poetical dialect, he will find that the words are in general well-ſounding, and ſuch as may coaleſce with other words, without producing harſh combinations. Quintilian obſerves, that poets, for the ſake of their verſe, are indulged in many liberties, not granted to the orator, of lengthening, ſhortening, and dividing their words*:— and if the Greek and Roman poets claimed this indulgence

* *Inſtit. Orat.* lib. x. cap. 1. § 7.

(D) Dryden in one place (Æneid ix. verſ. 1095.) uſes *Falſified* to denote *Pierced through and through.* He acknowledges, that this uſe of the word is an innovation; and has nothing to plead for it but his own authority, and that *Falſare* in Italian ſometimes means the ſame thing.

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gence from neceſſity, and obtained it, the Engliſh, thoſe of them eſpecially who write in rhyme, may claim it with better reaſon; as the words of their language are leſs muſical and far leſs ſuceptible of variety in arrangement and ſyntax.

50
and ſolemn.

Secondly, Such poetical words as are known to be ancient have ſomething venerable in their appearance, and impart a ſolemnity to all around them. This remark is from Quintilian; who adds, that they give to a compoſition that caſt and colour of antiquity which in painting is ſo highly valued, but which art can never effectually imitate *. Poetical words that are either not ancient, or not known to be ſuch, have, however, a pleaſing effect from aſſociation. We are accuſtomed to meet with them in ſublime and elegant writing; and hence they come to acquire ſublimity and elegance: Even as the words we hear on familiar occaſions come to be accounted familiar; and as thoſe that take their riſe among pick-pockets, gamblers, and gypſies, are thought too indelicate to be uſed by any perſon of taſte or good manners. When one hears the following lines, which abound in poetical words,

> The breezy call of incenſe-breathing morn,
> The ſwallow twittering from the ſtraw-built ſhed,
> The cock's ſhrill clarion, or the echoing horn,
> No more ſhall rouſe them from their lowly bed:

—one is as ſenſible of the dignity of the language, as one would be of the vileneſs or vulgarity of that man's ſpeech, who ſhould prove his acquaintance with Bridewell, by interlarding his diſcourſe with ſuch terms as *mill-doll*, *queer cull*, or *nobbing cheat* †; or who, in imitation of fops and gamblers, ſhould on the common occaſions of life, talk of being *beat hollow*, or *ſaving his diſtance* ‡. What gives dignity to perſons gives dignity to language. A man of this character is one who has borne important employments, been connected with honourable aſſociates, and never degraded himſelf by levity or immorality of conduct. Dignified phraſes are thoſe which have been uſed to expreſs elevated ſentiments, have always made their appearance in elegant compoſition, and have never been profaned by giving permanency or utterance to the paſſions of the vile, the giddy, or the worthleſs. And as by an active old age, the dignity of ſuch men is confirmed and heightened; ſo the dignity of ſuch words, if they be not ſuffered to fall into diſuſe, ſeldom fails to improve by length of time.

* Lib. viii. cap. 3.

† See the *Scoundrel's Dictionary*.

‡ Language of New-market.

Art. II. Of Tropes and Figures.

51
Tropes and figures neceſſary to poetical language,

If it appear that, by means of figures, language may be made more *pleaſing* and more natural than it would be without them; it will follow, that to poetic language, whoſe end is to *pleaſe* by imitating *nature*, figures muſt be not only ornamental, but neceſſary. It will here be proper, therefore, firſt to point out the importance and utility of figurative language; ſecondly, to ſhow, that figures are more neceſſary to poetry in general than to any other mode of writing.

I. *As to the importance and utility of figurative expreſſion*, in making language more pleaſing and more natural; it may be remarked,

52
to ſupply the defects of ſimple language, and

(1.) That tropes and figures are often neceſſary to ſupply the unavoidable defects of language. When *proper* words are wanting, or not recollected, or when we do not chooſe to be always repeating them, we muſt have recourſe to tropes and figures. When philoſophers began to explain the operations of the mind, they found that moſt of the words in common uſe, being framed to anſwer the more obvious exigencies of life, were in their proper ſignification applicable to matter only and its qualities. What was to be done in this caſe? Would they think of making a new language to expreſs the qualities of mind? No: that would have been difficult or impracticable; and granting it both practicable and eaſy, they muſt have foreſeen, that nobody would read or liſten to what was thus ſpoken or written in a new and conſequently in an unknown tongue. They therefore took the language as they found it; and whereever they thought there was a ſimilarity or analogy between the qualities of the mind and the qualities of matter, ſcrupled not to uſe the names of the material qualities tropically, by applying them to the mental qualities. Hence came the phraſes *ſolidity* of judgement, *warmth* of imagination, *enlargement* of underſtanding, and many others; which, though figurative, expreſs the meaning juſt as well as proper words would have done. In fact, numerous as the words in every language are, they muſt always fall ſhort of the unbounded variety of human thoughts and perceptions. Taſtes and ſmells are almoſt as numerous as the ſpecies of bodies. Sounds admit of perceptible varieties that ſurpaſs all computation, and the ſeven primary colours may be diverſified without end. If each variety of external perception were to have a name, language would be inſurmountably difficult; nay, if men were to appropriate a claſs of names to each particular ſenſe, they would multiply words exceedingly, without adding any thing to the clearneſs of ſpeech. Thoſe words, therefore, that in their proper ſignification denote the objects of one ſenſe, we often apply tropically to the objects of another, and ſay, Sweet taſte, ſweet ſmell, ſweet ſound; ſharp point, ſharp taſte, ſharp ſound; harmony of ſounds, harmony of colours, harmony of parts; ſoft ſilk, ſoft colour, ſoft ſound, ſoft temper; and ſo in a thouſand inſtances: and yet theſe words, in their tropical ſignification, are not leſs intelligible than in their proper one; for ſharp taſte and ſharp ſound, are as expreſſive as ſharp ſword; and harmony of tones is not better underſtood by the muſician, than harmony of parts by the architect, and harmony of colours by the painter.

Savages, illiterate perſons, and children, have comparatively but few words in proportion to the things they may have occaſion to ſpeak of; and muſt therefore recur to tropes and figures more frequently than perſons of copious elocution. A ſeaman, or mechanic, even when he talks of that which does not belong to his art, borrows his language from that which does; and this makes his diction figurative to a degree that is ſometimes entertaining enough. "Death (ſays a ſeaman in one of Smollet's novels) has not yet *boarded* my comrade; but they have been *yard-arm and yard-arm* theſe *three glaſſes*. His *ſtarboard* eye is open, but faſt *jammed* in his head; and the *haulyards* of his under jaw have given way." Theſe phraſes are exaggerated; but we allow them to be natural, becauſe we know that illiterate people are apt to make uſe of tropes and figures taken from their own trade, even when they ſpeak of things that are very remote and incongruous. In thoſe poems, therefore, that imitate the converſation of illiterate perſons, as in comedy, farce, and paſtoral, ſuch figures judiciouſly

Of Tropes and Figures.

dicioufly applied may render the imitation more pleafing, becaufe more exact and natural.

53 to avoid harfhnefs of diction.

Words that are untuneable and harfh, the poet is often obliged to avoid, when perhaps he has no other way to exprefs their meaning than by tropes and figures; and fometimes the meafure of his verfe may oblige him to reject a proper word that is not harfh, merely on account of its being too long, or too fhort, or in any other way unfuitable to the rhythm, or to the rhyme. And hence another ufe of figurative language, that it contributes to poetical harmony. Thus, *to prefs the plain*, is frequently ufed to fignify *to be flain in battle*; *liquid plain* is put for *ocean*, *blue ferene* for *fky*, and *fylvan reign* for *country life*.

54 Tropes and figures favourable to delicacy;

(2.) Tropes and figures are favourable to delicacy. When the proper name of a thing is in any refpect unpleafant, a well chofen trope will convey the idea in fuch a way as to give no offence. This is agreeable, and even neceffary, in polite converfation, and cannot be difpenfed with in elegant writing of any kind. Many words, from their being often applied to vulgar ufe, acquire a meannefs that difqualifies them for a place in ferious poetry; while perhaps, under the influence of a different fyftem of manners, the correfponding words in another language may be elegant, or at leaft not vulgar. When one reads Homer in the Greek, one takes no offence at his calling Eumeus by a name which, literally rendered, fignifies *fwine-herd*; firft, becaufe the Greek word is well-founding in itfelf; fecondly, becaufe we have never heard it pronounced in converfation, nor confequently debafed by vulgar ufe; and, thirdly, becaufe we know, that the office denoted by it was, in the age of Eumeus, both important and honourable. But Pope would have been blamed, if a name fo indelicate as *fwine-herd* had in his tranflation been applied to fo eminent a perfonage; and therefore he judicioufly makes ufe of the trope *fynecdoche*, and calls him *fwain* *; a word both elegant and poetical, and not likely to lead the reader into any miftake about the perfon fpoken of, as his employment had been defcribed in a preceding paffage. The fame Eumeus is faid, in the fimple but melodious language of the original, to have been making his own fhoes when Ulyffes came to his door; a work which in thofe days the greateft heroes would often find neceffary. This, too, the tranflator foftens by a tropical expreffion:

* Odyffey, book xiv. ver. 41.

> Here fat Eumenus, and his cares applied,
> To form ftrong *bufkins* of well feafoned hide.

A hundred other examples might be quoted from this tranflation; but thefe will explain our meaning.

There are other occafions on which the delicacy of figurative language is ftill more needful; as in Virgil's account of the effects of animal love, and of the plague among the beafts, in the third Georgic; where Dryden's ftyle, by being lefs figurative than the original, is in one place exceedingly filthy, and in another fhockingly obfcene.

Hobbes could conftrue a Greek author; but his fkill in words muft have been all derived from the dictionary; for he feems not to have known that any one articulate found could be more agreable, or any one phrafe more dignified than another. In his Iliad and Odyffey, even when he hits the author's fenfe (which is not always the cafe), he proves, by his choice of words, that of harmony, elegance, or energy of ftyle, he had no manner of conception. And hence that work, though called a *Tranflation of Homer*, does not even deferve the name of *poem*; becaufe it is in every refpect unpleafing, being nothing more than a fictitious narrative delivered in a mean profe, with the additional meannefs of harfh rhyme and untuneable meafure.—Trapp underftood Virgil well enough as a grammarian, and had a tafte for his beauties: yet his tranflation bears no refemblance to Virgil; which is owing to the fame caufe, an imprudent choice of words and figures, and a total want of harmony.

55 which, however, may be carried too far.

The delicacy we here contend for may, indeed, both in converfation and in writing, be carried too far. To call *killing an innocent man in a duel* an affair of honour, and *a violation of the rights of wedlock* an affair of gallantry, is a proftitution of figurative language. Nor is it any credit to us, that we are faid to have upwards of 40 figurative phrafes to exprefs exceffive drinking. Language of this fort generally implies, that the public abhorrence of fuch crimes is not fo ftrong as it ought to be: and it is a queftion, whether even our morals might not be improved, if we were to call thefe and fuch like crimes by their proper names, *murder*, *adultery*, *drunkennefs*, *gluttony*; names that not only exprefs our meaning, but alfo betoken our difapprobation.—As to writing, it cannot be denied, that even Pope himfelf, in the excellent verfion juft now quoted, has fometimes, for the fake of his numbers, or for fear of giving offence by too clofe an imitation of Homer's fimplicity, employed tropes and figures too quaint or too folemn for the occafion. And the finical ftyle is in part characterifed by the writer's diflike to literal expreffions, and affectedly fubftituting in their ftead unneceffary tropes and figures. With thefe authors, a man's only child muft always be his *only hope*; a country maid becomes *a rural beauty*, or perhaps a *nymph of the groves*; if flattery fing at all, it muft be a *fyren fong*; the fhepherd's flute dwindles into an *oaten reed*, and his crook is exalted into a *fceptre*; the *filver lilies* rife from their *golden beds*, and *languifh* to the *complaining* gale. A young woman, though a good Chriftian, cannot make herfelf agreeable without *facrificing to the Graces*; nor hope to do any execution among the *gentle fwains*, till a whole legion of *Cupids*, armed with *flames* and *darts*, and other weapons, begin to difcharge from her eyes their formidable artillery. For the fake of variety, or of the verfe, fome of thefe figures may now and then find a place in a poem; but in profe, unlefs very fparingly ufed, they favour of affectation.

56 Tropes and figures promote brevity, and

(3.) Tropes and figures promote brevity; and brevity, united with perfpicuity, is always agreeable. An example or two will be given in the next paragraph. Sentiments thus delivered, and imagery, thus painted, are readily apprehended, by the mind, make a ftrong impreffion upon the fancy, and remain long in the memory; whereas too many words, even when the meaning is good, never fail to bring difguft and wearinefs. They argue a debility of mind which hinders the author from feeing his thoughts in one diftinct point of view; and they alfo encourage a fufpicion, that there is fomething faulty or defective in the matter. In the poetic ftyle, therefore, which is addreffed to the fancy and paffions, and intended to make a vivid, a pleafing, and a permanent impreffion, brevity, and confequently tropes and figures, are indifpenfable. And a language will always

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be the better ſuited to poetical purpoſes, the more it admits of this brevity;—a character which is more conſpicuous in the Greek and Latin than in any modern tongue, and much leſs in the French than in the Italian or Engliſh.

57 contribute to ſtrength and energy of language.

(4.) Tropes and figures contribute to ſtrength or energy of language, not only by their conciſeneſs, but alſo by conveying to the fancy ideas that are eaſily comprehended, and make a ſtrong impreſſion. We are powerfully affected with what we ſee, or feel, or hear. When a ſentiment comes enforced or illuſtrated by figures taken from objects of ſight, or touch, or hearing, one thinks, as it were, that one ſees, or feels, or hears, the thing ſpoken of; and thus, what in itſelf would perhaps be obſcure, or is merely intellectual, may be made to ſeize our attention and intereſt our paſſions almoſt as effectually as if it were an object of outward ſenſe. When Virgil calls the Scipios *thunderbolts of war*, he very ſtrongly expreſſes in one word, and by one image, the rapidity of their victories, the noiſe their atchievements made in the world, and the ruin and conſternation that attended their irreſiſtible career.—When Homer calls Ajax *the bulwark of the Greeks*, he paints with equal brevity his vaſt ſize and ſtrength, the difficulty of prevailing againſt him, and the confidence wherewith his countrymen repoſed on his valour.—When Solomon ſays of the ſtrange woman, or harlot, that "her feet go *down* to death," he lets us know, not only that her path ends in deſtruction, but alſo, that they who accompany her will find it eaſy to go forwards to ruin, and difficult to return to their duty.—Satan's enormous magnitude, and refulgent appearance, his perpendicular aſcent through a region of darkneſs, and the inconceivable rapidity of his motion, are all painted out to our fancy by Milton, in one very ſhort ſimilitude,

Sprung upward, like—a pyramid of fire.
Par. Loſt. iv. 1013.

To take in the full meaning of which figure, we muſt imagine ourſelves in chaos, and a vaſt luminous body riſing upwards, near the place where we are, ſo ſwiftly as to appear a continued track of light, and leſſening to the view according to the increaſe of diſtance, till it end in a point, and then diſappear; and all this muſt be ſuppoſed to ſtrike our eye at one inſtant.——Equal to this in propriety, though not in magnificence, is that allegory of Gray,

The paths of glory lead but to the grave:

Which preſents to the imagination a wide plain, where ſeveral roads appear, crowded with glittering multitudes, and iſſuing from different quarters, but drawing nearer and nearer as they advance, till they terminate in the dark and narrow houſe, where all their glories enter in ſucceſſion, and diſappear for ever.——When it is ſaid in Scripture, of a good man who died, that he *fell aſleep*, what a number of ideas are at once conveyed to our imagination, by this beautiful and expreſſive figure: As a labourer, at the cloſe of day, goes to ſleep, with the ſatisfaction of having performed his work, and with the agreeable hope of awaking in the morning of a new day, refreſhed and cheerful; ſo a good man, at the end of life, reſigns himſelf calm and contented to the will of his Maker, with the ſweet reflection of having endeavoured to do his duty, and with the tranſporting hope of ſoon awaking in the regions of light, to life and happineſs eternal. The figure alſo ſuggeſts, that to a good man the tranſition from life to death is, even in the ſenſation, no more painful, than when our faculties melt away into the pleaſing inſenſibility of ſleep.——Satan, flying among the ſtars, is ſaid by Milton to "*ſail* between worlds and worlds;" which has an elegance and force far ſuperior to the proper word *fly*. For by this alluſion to a ſhip, we are made to form a lively idea of his great ſize, and to conceive of his motion, that it was equable and majeſtic.——Virgil uſes a happy figure to expreſs the ſize of the great wooden horſe, by means of which the Greeks were conveyed into Troy: "Equum divina Palladis arte *ædificant*."——Milton is ſtill bolder when he ſays,

Who would not ſing for Lycidas! he knew
Himſelf to ſing, and *build the lofty rhyme*.

The phraſe, however, though bold, is emphatical; and gives a noble idea of the durability of poetry, as well as of the art and attention requiſite to form a good poem.——There are hundreds of tropical expreſſions in common uſe, incomparably more energetic than any proper words of equal brevity that could be put in their place. A cheek *burning* with bluſhes, is a trope which at once deſcribes the colour as it appears to the beholder, and the glowing heat as it is felt by the perſon bluſhing. *Chilled* with deſpondence, *petrified* with aſtoniſhment, *thunderſtruck* with diſagreeable and unexpected intelligence, *melted* with love or pity, *diſſolved* in luxury, *hardened* in wickedneſs, *ſoftening* into remorſe, *inflamed* with deſire, *toſſed* with uncertainty, &c.—every one is ſenſible of the force of theſe and the like phraſes, and that they muſt contribute to the energy of compoſition.

(5.) Tropes and figures promote ſtrength of expreſſion; and are in poetry peculiarly requiſite, becauſe they are often more *natural*, and more *imitative*, than proper words. In fact, this is ſo much the caſe, that it would be impoſſible to imitate the language of paſſion without them. It is true, that when the mind is agitated, one does not run out into allegories, or long-winded ſimilitudes, or any of the figures that require much attention and many words, or that tend to withdraw the fancy from the object of the paſſion. Yet the language of many paſſions muſt be figurative notwithſtanding; becauſe they rouſe the fancy, and direct it to objects congenial to their own nature, which diverſify the language of the ſpeaker with a multitude of alluſions. The fancy of a very angry man, for example, preſents to his view a train of diſagreeable ideas connected with the paſſion of anger, and tending to encourage it; and if he ſpeak without reſtraint during the paroxyſm of his rage, thoſe ideas will force themſelves upon him, and compel him to give them utterance. "Infernal monſter! (he will ſay),—my blood boils at him; he has uſed me like a dog; never was man ſo injured as I have been by this barbarian. He has no more ſenſe of propriety than a ſtone. His countenance is diabolical, and his ſoul as ugly as his countenance. His heart is cold and hard, and his reſolutions dark and bloody," &c. This ſpeech is wholly figurative. It is made up of *metaphors* and *hyperboles*, which, with the *proſopopeia* and *apoſtrophe*, are the moſt paſſionate of all the figures. Lear, driven out of doors by his unnatural daughters, in the midſt of darkneſs, thunder, and tempeſt, naturally

58 They are likewiſe the language of ſtrong paſſion.

rally breaks forth (for his indignation is juſt now raiſed to the very higheſt pitch) into the following violent exclamation againſt the crimes of mankind, in which almoſt every word is figurative.

Tremble, thou wretch,
That haſt within thee undivulged crimes
Unwhipt of juſtice. Hide thee, thou bloody hand,
Thou perjur'd, and thou ſimular of virtue,
That art inceſtuous. Caitiff, to pieces ſhake,
That under covert, and convenient ſeeming,
Haſt practis'd on man's life. Cloſe pent-up guilts,
Rive your concealing continents, and cry
Theſe dreadful ſummoners grace. *King Lear.*

——The vehemence of maternal love, and ſorrow from the apprehenſion of loſing her child, make the Lady Conſtance utter a language that is ſtrongly figurative, though quite ſuitable to the condition and character of the ſpeaker. The paſſage is too long for a quotation, but concludes thus:

O Lord! my boy, my Arthur, my fair ſon,
My life, my joy, my food, my all the world,
My widow-comfort, and my ſorrow's cure. *King John.*

——Similar to this, and equally expreſſive of conjugal love, is that beautiful hyperbole in Homer; where Andromache, to diſſuade her huſband from going out to the battle, tells him that ſhe had now no mother, father, or brethren, all her kindred being dead, and her native country deſolate; and then tenderly adds,

But while my Hector yet ſurvives, I ſee
My father, mother, brethren, all in thee. *Iliad*, b. vi.

59 The ſimpleſt language moſt ſuitable to depreſſing paſſions,

As the paſſions that agitate the ſoul, and rouſe the fancy, are apt to vent themſelves in tropes and figures, ſo thoſe that depreſs the mind adopt for the moſt part a plain diction without any ornament: for to a dejected mind, wherein the imagination is generally inactive, it is not probable that any great variety of ideas will preſent themſelves; and when theſe are few and familiar, the words that expreſs them muſt be ſimple. As no author equals Shakeſpeare in boldneſs or variety of figures when he copies the ſtyle of thoſe violent paſſions that ſtimulate the fancy; ſo, when he would exhibit the human mind in a dejected ſtate, no uninſpired writer excels him in ſimplicity. The ſame Lear whoſe reſentment had impaired his underſtanding, while it broke out in the moſt boiſterous language, when, after ſome medical applications, he recovers his reaſon, his rage being now exhauſted, his pride humbled, and his ſpirits totally depreſſed, ſpeaks in a ſtyle than which nothing can be imagined more ſimple or more affecting.

Pray, do not mock me:
I am a very fooliſh, fond old man,
Fourſcore and upward; and, to deal plainly with you,
I fear I am not in my perfect mind.
Methinks I ſhould know you, and know this man;
Yet I am doubtful: for I am mainly ignorant
What place this is; and all the ſkill I have
Remembers not theſe garments: nor I know not
Where I did lodge laſt night. *Lear*, Act iv. ſc. 7.

——Deſdemona, ever gentle, artleſs, and ſincere, ſhocked at the unkindneſs of her huſband, and overcome with melancholy, ſpeaks in a ſtyle ſo beautifully ſimple, and ſo perfectly natural, that one knows not what to ſay in commendation of it:

My mother had a maid call'd Barbara;
She was in love, and he ſhe lov'd prov'd falſe,
And did forſake her. She had a ſong of willow;
An old thing it was, but it expreſs'd her fortune,
And ſhe died ſinging it. That ſong to-night
Will not go from my mind: I have much to do,
But to go hang my head all at one ſide,
And ſing it like poor Barbara. *Othello*, Act iv. ſc. 3.

Sometimes the imagination, even when exerted to the utmoſt, takes in but few ideas. This happens when the attention is totally engroſſed by ſome very great object; admiration being one of thoſe emotions that rather ſuſpend the exerciſe of the faculties than puſh them into action. And here, too, the ſimpleſt language is the moſt natural; as when Milton ſays of the Deity, that he ſits "high-throned above all height." And as this ſimplicity is more ſuitable to that one great exertion which occupies the ſpeaker's mind than a more elaborate imagery or language would have been, ſo has it alſo a more powerful effect in fixing and elevating the imagination of the hearer; for to introduce other thoughts for the ſake of illuſtrating what cannot be illuſtrated, could anſwer no other purpoſe than to draw off the attention from the principal idea. In theſe and the like caſes, the fancy left to itſelf will have more ſatisfaction in purſuing at leiſure its own ſpeculations than in attending to thoſe of others; as they who ſee for the firſt time ſome admirable object would chooſe rather to feaſt upon it in ſilence, than to have their thoughts interrupted by a long deſcription from another perſon, informing them of nothing but what they ſee before them, are already acquainted with, or may eaſily conceive.

60 and to the ſentiment of admiration.

It was remarked above that the *hyperbole*, *proſopopeia*, and *apoſtrophe*, are among the moſt paſſionate figures. This deſerves illuſtration.

61 Hyperbole natural to the paſſion of anger, love, fear, &c.

1ſt, A very angry man is apt to think the injury he has juſt received greater than it really is; and if he proceed immediately to retaliate by word or deed, ſeldom fails to exceed the due bounds, and to become injurious in his turn. The fond parent looks upon his child as a prodigy of genius and beauty; and the romantic lover will not be perſuaded that his miſtreſs has nothing ſupernatural either in her mind or perſon. Fear, in like manner, not only magnifies its object when real, but even forms an object out of nothing, and miſtakes the fictions of fancy for the intimations of ſenſe.—No wonder, then, that they who ſpeak according to the impulſe of paſſion ſhould ſpeak *hyperbolically*; that the angry man ſhould exaggerate the injury he has received, and the vengeance he is going to inflict; that the ſorrowful ſhould magnify what they have loſt, and the joyful what they have obtained; that the lover ſhould ſpeak extravagantly of the beauty of his miſtreſs, the coward of the dangers he has encountered, and the credulous clown of the miracles performed by the juggler. In fact, theſe people would not do juſtice to what they feel if they did not ſay more than the truth. The valiant man, on the other hand, as naturally adopts the diminiſhing hyperbole when he ſpeaks of danger; and the man of ſenſe, when he is obliged to mention his own virtue or ability; becauſe it appears to him, or he is willing to conſider

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consider it, as less than the truth, or at best as inconsiderable. Contempt uses the same figure; and therefore Petruchio, affecting that passion, affects also the language of it:

> Thou liest, thou thread, thou thimble,
> Thou yard, three-quarters, half-yard, quarter, nail,
> Thou flea, thou nit, thou winter-cricket, thou!
> Brav'd in mine own house with a skein of thread!
> Away, thou rag, thou quantity, thou remnant!
>
> *Taming of the Shrew*, Act iv. sc. 1.

For some passions consider their objects as important, and others as unimportant. Of the former sort are anger, love, fear, admiration, joy, sorrow, pride; of the latter are contempt and courage. Those may be said to subdue the mind to the object, and these to subdue the object to the mind. And the former, when violent, always magnify their objects: whence the hyperbole called amplification, or *auxesis*: and the latter as constantly diminish theirs; and give rise to the hyperbole called *meiosis*, or diminution.—Even when the mind cannot be said to be under the influence of any violent passion, we naturally employ the same figure when we would impress another very strongly with any idea. "He is a walking shadow: he is worn to skin and bone; he has one foot in the grave and the other following:"—these, and the like phrases, are proved to be natural by their frequency. By introducing great ideas, the hyperbole is further useful in poetry as a source of the sublime; but when employed injudiciously is very apt to become ridiculous. Cowley makes Goliah as big as the hill down which he was marching *; and tells us, that when he came into the valley he seemed to fill it, and to overtop the neighbouring mountains (which, by the by, seems rather to lessen the mountains and valleys than to magnify the giant): nay, he adds, that the sun started back when he saw the splendour of his arms. This poet seems to have thought that the figure in question could never be sufficiently enormous; but Quintilian would have taught him, "Quamvis omnis hyperbole ultra fidem, non tamen esse debet ultra modum." The reason is, that this figure, when excessive, betokens rather absolute infatuation than intense emotion; and resembles the efforts of a ranting tragedian, or the ravings of an enthusiastic declaimer, who, by putting on the gestures and looks of a lunatic, satisfy the discerning part of their audience, that, instead of feeling strongly, they have no rational feelings at all. In the wildest energies of nature there is a modesty which the imitative artist will be careful never to overstep.

* *Davideis*, book iii.

62 Prosopopœia, when proper.

2dly, That figure, by which things are spoken of as if they were persons, is called *prosopopœia*, or *personification*. It is a bold figure, and yet is often natural. Long acquaintance recommends to some share in our affection even things inanimate, as a house, a tree, a rock, a mountain, a country; and were we to leave such a thing without hope of return, we should be inclined to address it with a farewel, as if it were a percipient creature. Hence it was that Mary queen of Scotland, when on her return to her own kingdom, so affectionately bade adieu to the country which she had left. "Farewel France," said she; "farewel, beloved country, which I shall never more behold!" Nay, we find that ignorant nations have actually worshipped such things, or considered them as the haunt of certain powerful beings. Dryads and hamadryads were by the Greeks and Romans supposed to preside over trees and groves; river gods and nymphs, over streams and fountains; little deities, called *Lares* and *Penates*, were believed to be the guardians of hearths and houses. In Scotland there is hardly a hill remarkable for the beauty of its shape, that was not in former times thought to be the habitation of fairies. Nay, modern as well as ancient superstition has appropriated the waters to a peculiar sort of demon or goblin, and people the very regions of death, the tombs and charnel-houses, with multitudes of ghosts and phantoms.—Besides, when things inanimate make a strong impression upon us, whether agreeable or otherwise, we are apt to address them in terms of affection or dislike. The sailor blesses the plank that brought him ashore from the shipwreck; and the passionate man, and sometimes even the philosopher, will say bitter words to the stumbling block that gave him a fall.—Moreover, a man agitated with any interesting passion, especially of long continuance, is apt to fancy that all nature sympathises with him. If he has lost a beloved friend, he thinks the sun less bright than at other times; and in the sighing of the winds and groves, in the lowings of the herd, and in the murmurs of the stream, he seems to hear the voice of lamentation. But when joy or hope predominate, the whole world assumes a gay appearance. In the contemplation of every part of nature, of every condition of mankind, of every form of human society, the benevolent and the pious man, the morose and the cheerful, the miser and the misanthrope, finds occasion to indulge his favourite passion, and sees, or thinks he sees, his own temper reflected back in the actions, sympathies, and tendencies of other things and persons. Our affections are indeed the medium through which we may be said to survey ourselves, and every thing else; and whatever be our inward frame, we are apt to perceive a wonderful congeniality in the world without us. And hence the fancy, when roused by real emotions, or by the pathos of composition, is easily reconciled to those figures of speech that ascribe sympathy, perception, and the other attributes of animal life, to things inanimate, or even to notions merely intellectual.—Motion, too, bears a close affinity to action, and affects our imagination nearly in the same manner; and we see a great part of nature in motion, and by its sensible effects are led to contemplate energies innumerable. These conduct the rational mind to the Great First Cause; and these, in times of ignorance, disposed the vulgar to believe in a variety of subordinate agents employed in producing those appearances that could not otherwise be accounted for. Hence an endless train of fabulous deities, and of witches, demons, fairies, genii; which, if they prove our reason weak and our fancy strong, prove also that personification is natural to the human mind; and that a right use of this figure may have a powerful effect, in fabulous writing especially, to engage our sympathy in behalf of things as well as persons: for nothing can give lasting delight to a moral being, but that which awakens sympathy, and touches the heart; and though it be true that we sympathise in some degree even with inanimate things, yet what has, or is supposed to have, life, calls forth a more sincere and more permanent fellow-feeling.—Let it be observed further, that to awaken our sympathetic feelings, a lively conception of their object is necessary. This indeed is true of almost all our emotions; their keenness is in proportion

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portion to the vivacity of the perceptions that excite them. Diftrefs that we fee is more affecting than what we only hear of *; a perufal of the gayeft fcenes in a comedy does not roufe the mind fo effectually as the prefence of a cheerful companion; and the death of a friend is of greater energy in producing ferioufnefs, and the confideration of our latter end, than all the pathos of Young. Of defcriptions addreffed to the fancy, thofe that are moft vivid and picturefque will generally be found to have the moft powerful influence over our affections; and thofe that exhibit perfons engaged in action, and adorned with vifible infignia, give a brifker impulfe to the faculties than fuch as convey intellectual ideas only, or images taken from ftill life. No abftract notion of time, or of love, can be fo ftriking to the fancy as the image of an old man accoutred with a fcythe, or of a beautiful boy with wings and a bow and arrows: and no phyfiological account of frenzy could fuggeft fo vivid an idea as the poet has given us in that exquifite portrait,

* Hor. Ar. Poet. v. 180.

And moody madnefs laughing wild amid fevereft wo.

And for this reafon partly it is that the epic poet, in order to work the more effectually upon our paffions and imagination, refers the fecret fprings of human conduct, and the viciffitudes of human affairs, to the agency of perfonified caufes; that is, to the machinery of gods and goddeffes, angels, demons, magicians, and other powerful beings. And hence, in all fublime poetry, life and motion, with their feveral modes and attributes, are liberally beftowed on thofe objects wherewith the author intends that we fhould be ftrongly impreffed: fcenes perfectly inanimate and ftill, tending rather to diffufe a languor over the mind than to communicate to our internal powers thofe lively energies without which a being effentially active can never receive complete gratification. —Laftly, fome violent paffions are peculiarly inclined to change things into perfons. The horrors of his mind haunted Oreftes in the fhape of furies. Confcience, in the form of the murdered perfon, ftares the murderer in the face, and often terrifies him to diftraction. The fuperftitious man, travelling alone in the dark, miftakes a white ftone for a ghoft, a bufh for a demon, a tree waving with the wind for an enormous giant brandifhing a hundred arms. The lunatic and enthufiaft converfe with perfons who exift only in their own diftempered fancy; and the glutton and the mifer, if they were to give utterance to all their thoughts, would often, it is prefumable, fpeak, the one of his gold, the other of his belly, not only as a perfon, but as a god,—the object of his warmeft love and moft devout regard.—More need not be faid to prove that perfonification is natural, and may frequently contribute to the pathos, energy, and beauty of poetic language.

63 Apoftrophe how to be ufed.

3dly, *Apoftrophe*, or a fudden diverfion of fpeech from one perfon to another perfon or thing, is a figure nearly related to the former. Poets fometimes make ufe of it, in order to help out their verfe, or merely to give variety to their ftyle: but on thefe occafions it is to be confidered as rather a trick of art, than an effort of nature. It is moft natural, and moft pathetic, when the perfon or thing to whom the apoftrophe is made, and for whofe fake we give a new direction to our fpeech, is in our eyes eminently diftinguifhed for good or evil, or raifes with us fome fudden and powerful emotion, fuch as the hearer would acquiefce in, or at leaft acknowledge to be reafonable. But this, like the other pathetic figures, muft be ufed with great prudence. For if, inftead of calling forth the hearer's fympathy, it fhould only betray the levity of the fpeaker, or fuch wanderings of his mind as neither the fubject nor the occafion would lead one to expect, it will then create difguft inftead of approbation. The orator, therefore, muft not attempt the paffionate apoftrophe, till the minds of the hearers be prepared to join in it. And every audience is not equally obfequious in this refpect. In the forum of ancient Rome that would have paffed for fublime and pathetic, which in the moft refpectable Britifh auditories would appear ridiculous. For our ftyle of public fpeaking is cool and argumentative; and partakes lefs of enthufiafm than the Roman did, and much lefs than the modern French or Italian. Of Britifh eloquence, particularly that of the pulpit, the chief recommendations are gravity and fimplicity. And it is vain to fay, that our oratory *ought* to be more vehement: for that matter depends on caufes, which it is not only inexpedient, but impoffible to alter; namely, on the character and fpirit of the people, and their rational notions in regard to religion, policy, and literature. The exclamations of Cicero would weigh but little in our parliament; and many of thofe which we meet with in French fermons would not be more effectual if attempted in our pulpit. To fee one of our preachers, who the moment before was a cool reafoner, a temperate fpeaker, an humble Chriftian, and an orthodox divine, break out into a fudden apoftrophe to the immortal powers, or to the walls of the church, tends to force a fmile, rather than a tear, from thofe among us who reflect, that there is nothing in the fubject, and fhould be nothing in the orator, to warrant fuch wanderings of fancy or vehemence of emotion. If he be careful to cultivate a pure ftyle, and a grave and graceful utterance, a Britifh clergyman, who fpeaks from conviction the plain unaffected words of truth and fobernefs, of benevolence and piety, will, it is believed, convey more pathetic, as well as more permanent, impreffions to the heart, and be more ufeful as a Chriftian teacher, than if he were to put in practice all the attitudes of Rofcius, and all the tropes and figures of Cicero.

But where the language of paffion and enthufiafm is permitted to difplay itfelf, whatever raifes any ftrong emotion, whether it be animated or inanimate, abfent or prefent, fenfible or intellectual, may give rife to the apoftrophe. A man in a diftant country, fpeaking of the place of his birth, might naturally exclaim, "O my dear native land, fhall I never fee thee more!" Or, when fome great misfortune befals him, "Happy are ye, O my parents, that ye are not alive to fee this." We have a beautiful apoftrophe in the third book of the Æneid, where Æneas, who is telling his ftory to Dido, happening to mention the death of his father, makes a fudden addrefs to him as follows:

——— hic, pelagi tot tempeftatibus actus,
Heu, genitorem, omnis curæ cafufque levamen,
Amitto Anchifen:—hic me, pater optime, feffum
Deferis, heu, tantis nequicquam erepte periclis!

This apoftrophe has a pleafing effect. It feems to intimate, that the love which the hero bore his father was fo great, that when he mentioned him he forgot every thing

Of Tropes and Figures.

thing else; and, without minding his company, one of whom was a queen, suddenly addressed himself to that which, though present only in idea, was still a principal object of his affection. An emotion so warm and so reasonable cannot fail to command the sympathy of the reader.——When Michael, in the eleventh book of Paradise Lost, announces to Adam and Eve the necessity of their immediate departure from the garden of Eden, the poet's art in preserving the decorum of the two characters is very remarkable. Pierced to the heart at the thought of leaving that happy place, Eve, in all the violence of ungovernable sorrow, breaks forth into a pathetic apostrophe to Paradise, to the flowers she had reared, and to the nuptial bower she had adorned. Adam makes no address to the walks, the trees, or the flowers of the garden, the loss whereof did not so much afflict him; but, in his reply to the Archangel, expresses, without a figure, his regret for being banished from a place where he had been so often honoured with a sensible manifestation of the divine presence. The use of the apostrophe in the one case, and the omission of it in the other, not only gives a beautiful variety to the style, but also marks that superior elevation and composure of mind, by which the poet had all along distinguished the character of Adam.—One of the finest applications of this figure that is anywhere to be seen, is in the fourth book of the same poem; where the author, catching by sympathy the devotion of our first parents, suddenly drops his narrative, and joins his voice to theirs in adoring the Father of the universe.

> Thus at their shady lodge arriv'd, both stood,
> Both turn'd, and under open sky ador'd
> The God that made both sky, air, earth, and heav'n,
> Which they beheld, the moon's resplendent globe,
> And starry pole:—Thou also mad'st the night,
> Maker omnipotent! and thou the day,
> Which we in our appointed work employ'd
> Have finish'd.————

Milton took the hint of this fine contrivance from a well-known passage of Virgil:

> Hic juvenum chorus, ille senum; qui carmine laudes
> Herculeas et facta ferant;————
> ————ut duros mille labores
> Rege sub Eurystheo, fatis Junonis iniquæ,
> Pertulerit:—Tu nubigenas, invicte, bimembres,
> Hylæumque, Pholumque manu, tu Cresia mactas
> Prodigia.————

The beauty arising from diversified composition is the same in both, and very great in each. But every reader must *feel*, that the figure is incomparably more affecting to the mind in the imitation than in the original. So true it is, that the most rational emotions raise the most intense fellow-feeling; and that the apostrophe is then the most emphatical, when it displays those workings of human affection which are at once ardent and well-founded.

64
Tropes and figures are useful, as they suggest an endless variety of agreeable images.

To conclude this head: Tropes and figures, particularly the *metaphor*, *similitude*, and *allegory*, are further useful in beautifying language, by suggesting, together with the thoughts essential to the subject, an endless variety of agreeable images, for which there would be no place, if writers were always to confine themselves to the *proper* names of things. And this beauty and variety, judiciously applied, is so far from distracting, that it tends rather to fix the attention, and captivate the heart of the readers, by giving light, and life, and pathos, to the whole composition.

II. That tropes and figures are more necessary to poetry, than to any other mode of writing, was the second point proposed to be illustrated in this section.

65
Tropes and figures more necessary to poetry than to any other mode of writing.

Language, as already observed, is then natural, when it is suitable to the supposed condition of the speaker. Figurative language is peculiarly suitable to the supposed condition of the poet; because figures are suggested by the fancy; and the fancy of him who composes poetry is more employed than that of any other author. Of all historical, philosophical, and theological researches, the object is *real* truth, which is fixed and permanent. The aim of rhetorical declamation (according to Cicero) is *apparent* truth; which, being less determinate, leaves the fancy of the speaker more free, gives greater scope to the inventive powers, and supplies the materials of a more figurative phraseology. But the poet is subject to no restraints, but those of verisimilitude; which is still less determinate than rhetorical truth. He seeks not to convince the judgement of his reader by arguments of either real or apparent cogency; he means only to please and interest him, by an appeal to his sensibility and imagination. His own imagination is therefore continually at work, ranging through the whole of real and probable existence, "glancing from heaven to earth, from earth to heaven," in quest of images and ideas suited to the emotions he himself feels, and to the sympathies he would communicate to others. And, consequently, figures of speech, the offspring of excursive fancy, must (if he speak according to what he is supposed to think and feel, that is, according to his supposed condition) tincture the language of the poet more than that of any other composer. So that, if figurative diction be unnatural in geometry, because all wanderings of fancy are unsuitable, and even impossible, to the geometrician, while intent upon his argument; it is, upon the same principle, perfectly natural, and even unavoidable, in poetry; because the more a poet attends to his subject, and the better qualified he is to do it justice, the more active will his imagination be, and the more diversified the ideas that present themselves to his mind.——Besides, the true poet addresses himself to the passions and sympathies of mankind; which, till his own be raised, he cannot hope to do with success. And it is the nature of many passions, though not of all, to increase the activity of imagination: and an active imagination naturally vents itself in figurative language; nay, unless restrained by a correct taste, has a tendency to exceed in it; of which Bishop Taylor and Lord Verulam, two geniuses different in kind, but of the highest order, are memorable examples.

We said, that "the poet seeks not to convince the judgment of his reader by arguments of either real or apparent cogency."——We do not mean, that in poetry argument has no place. The most legitimate reasoning, the soundest philosophy, and narratives purely historical, may appear in a poem, and contribute greatly to the honour of the author, and to the importance of his work. All this we have in Paradise Lost. We mean, that what distinguishes *pure* poetry from other writing, is its aptitude, not to sway the judgment by reasoning,

Of Poetical Harmony.

ſoning, but to pleaſe the fancy, and move the paſſions, by a lively imitation of nature. Nor would we exclude poetical embelliſhment from hiſtory, or even from philoſophy. Plato's Dialogues and the Moral Eſſays of Addiſon and Johnſon abound in poetic imagery; and Livy and Tacitus often amuſe their readers with poetical deſcription. In like manner, though geometry and phyſics be different ſciences; though abſtract ideas be the ſubject, and pure demonſtration or intuition the evidence, of the former; and though the material univerſe, and the informations of ſenſe, be the ſubject and the evidence of the latter; yet have theſe ſciences been united by the beſt philoſophers, and very happy effects reſulted from the union.——In one and the ſame work, poetry, hiſtory, philoſophy, and oratory, may doubtleſs be blended; nay, theſe arts have all been actually blended in one and the ſame work, not by Milton only, but alſo by Homer, Virgil, Lucan, and Shakeſpeare. Yet ſtill theſe arts are different; different in their ends and principles, and in the faculties of the mind to which they are reſpectively addreſſed: and it is eaſy to perceive when a writer employs one and when another.

§ 2. *Of the* Sound *of Poetical Language.*

66 The poet ought to attend to the harmony of language, which conſiſts in

As the ear, like every other perceptive faculty, is capable of gratification, regard is to be had to the ſound of words, even in proſe. But to the harmony of language, it behoves the poet, more than any other writer, to attend; as it is more eſpecially his concern to render his work pleaſurable. In fact, we find, that no poet was ever popular who did not poſſeſs the art of harmonious compoſition.

What belongs to the ſubject of Poetical Harmony may be referred to one or other of theſe heads, *Sweetneſs*, *Meaſure*, and *Imitation*.

67 ſweetneſs and

I. In order to give *ſweetneſs* to language, either in verſe or proſe, all words of harſh ſound, difficult pronunciation, or unwieldy magnitude, are to be avoided as much as poſſible, unleſs when they have in the ſound ſomething peculiarly emphatical; and words are to be ſo placed in reſpect of one another, as that diſcordant combinations may not reſult from their union. But in poetry this is more neceſſary than in proſe; poetical language being underſtood to be an imitation of natural language improved to that perfection which is conſiſtent with probability. To poetry, therefore, a greater latitude muſt be allowed than to proſe, in expreſſing, by tropes and figures of pleaſing ſound, thoſe ideas whereof the proper names are in any reſpect offenſive, either to the ear or to the fancy.

II. How far verſification or *regular meaſure* may be eſſential to this art, has been diſputed by critical writers; ſome holding it to be indiſpenſably neceſſary, and ſome not neceſſary at all.

68 meaſure, which, though not eſſential,

The fact ſeems to be, as already hinted, that to poetry verſe is not eſſential. In a proſe work, we may have the fable, the arrangement, and a great deal of the pathos and language, of poetry; and ſuch a work is certainly a poem, though perhaps not a perfect one. For how abſurd would it be to ſay, that by changing the poſition only of a word or two in each line, one might diveſt Homer's Iliad of the poetical character! At this rate, the arts of poetry and verſification would be the ſame; and the rules in Deſpauter's Grammar, and the moral diſtichs aſcribed to Cato, would be as real poetry as any part of Virgil. In fact, ſome very ancient poems, when tranſlated into a modern tongue, are far leſs poetical in verſe than in proſe; the alterations neceſſary to adapt them to our numbers being detrimental to their ſublime ſimplicity; of which any perſon of taſte will be ſenſible, who compares our common proſe-verſion of Job, the Pſalms, and the Song of Solomon, with the beſt metrical paraphraſe of thoſe books that has yet appeared. Nay, in many caſes, Comedy will be more poetical, becauſe more pleaſing and natural, in proſe than in verſe. By verſifying Tom Jones, and The Merry Wives of Windſor, we ſhould ſpoil the two fineſt comic poems, the one epic, the other dramatical, now in the world.

69 adds to the perfection of poetry.

But, ſecondly, though verſe be not eſſential to poetry, it is neceſſary to the perfection of all poetry that admits of it. Verſe is to poetry, what colours are to painting (G). A painter might diſplay great genius, and draw maſterly figures with chalk or ink; but if he intend a perfect picture, he muſt employ in his work as many colours as are ſeen in the object he imitates. Or, to adopt a beautiful compariſon of Demoſthenes, quoted by Ariſtotle *, "Verſification is to poetry what bloom is to the human countenance." A good face is agreeable when the bloom is gone, and good poetry may pleaſe without verſification; harmonious numbers may ſet off an indifferent poem, and a fine bloom indifferent features: but, without verſe, poetry is incomplete; and beauty is not perfect, unleſs to ſweetneſs and regularity of feature there be ſuperadded

* *Rhetor.* lib. iii. cap. 4.

The bloom of young deſire, and purple light of love.

If numbers be neceſſary to the perfection of the higher poetry, they are no leſs ſo to that of the lower kinds, to Paſtoral, Song, and Satire, which have little beſides the language and verſification to diſtinguiſh them from proſe; and which ſome ancient authors are unwilling to admit to the rank of poems: though it ſeems too nice a ſcruple, both becauſe ſuch writings are commonly termed *poetical;* and alſo becauſe there is, even in them, ſomething that may not improperly be conſidered as an imitation of nature.

That the rhythm and meaſure of verſe are naturally agreeable, and therefore that by theſe poetry may be made more pleaſing than it would be without them, is evident from this, that children and illiterate people, whoſe admiration we cannot ſuppoſe to be the effect of habit or prejudice, are exceedingly delighted with them. In many proverbial ſayings, where there is neither rhime nor alliteration, rhythm is obviouſly ſtudied. Nay, the uſe of rhythm in poetry is univerſal; whereas alliteration and

(G) Horace ſeems to hint at the ſame compariſon, when, after ſpecifying the ſeveral ſorts of verſe ſuitable to Epic, Elegiac, Lyric, and Dramatic Poetry, he adds,

Deſcriptas ſervare vices, *operumque colores.*
Cur ego, ſi nequeo ignoroque, Poeta ſalutor? *Ar. Poet.* ver. 86.

Of Poetical Harmony.

and rhime, though relished by some nations, are not much sought after by others. And we need not be at a loss to account for the agreeableness of proportion and order, if we reflect, that they suggest the agreeable ideas of contrivance and skill, at the same time that they render the connection of things obvious to the understanding, and imprint it deeply on the memory. Verse, by promoting distinct and easy remembrance, conveys ideas to the mind with energy, and enlivens every emotion the poet intends to raise in the reader or hearer. Besides, when we attend to verses, after hearing one or two, we become acquainted with the measure, which, therefore, we always look for in the sequel. This perpetual interchange of hope and gratification is a source of delight; and to this in part is owing the pleasure we take in the rhimes of modern poetry. And hence we see, that though an incorrect rhime or untuneable verse be in itself, and compared with an important sentiment, a very trifling matter; yet it is no trifle in regard to its effects on the hearer; because it brings disappointment, and so gives a temporary shock to the mind, and interrupts the current of the affections; and because it suggests the disagreeable ideas of negligence or want of skill on the part of the author. And therefore, as the public ear becomes more delicate, the negligence will be more glaring, and the disappointment more intensely felt; and correctness of rhime and of measure will of course be the more indispensible. In our tongue, rhime is more necessary to Lyric than to Heroic poetry. The reason seems to be, that in the latter the ear can of itself perceive the boundary of the measure, because the lines are all of equal length nearly, and every good reader makes a short pause at the end of each; whereas, in the former, the lines vary in length: and therefore the rhime is requisite to make the measure and rhythm sufficiently perceptible. Custom too may have some influence. English Odes without rhime are uncommon; and therefore have something aukward about them, or something at least to which the public ear is not yet thoroughly reconciled. Indeed, when the drama is excepted, we do not think that rhime can be safely spared from English poetry of any kind, but when the subject is able to support itself. "He that thinks himself capable of astonishing (says Johnson) may write blank verse; but those that hope only to please, must condescend to rhime."

70
In what cases rhime may be dispensed with in English poetry.

Rhime, however, is of less importance by far than rhythm, which in poetry as well as in music is the source of much pleasing variety; of variety tempered with uniformity, and regulated by art; insomuch that, notwithstanding the likeness of one hexameter verse to another, it is not common, either in Virgil or Homer, to meet with two contiguous hexameters whose rhythm is exactly the same. And though all English heroic verses consist of five feet, among which the iambic predominates; yet this measure, in respect of rhythm alone, is susceptible of more than 30 varieties. And let it be remarked further, that different kinds of verse, by being adapted to different subjects and modes of writing, give variety to the poetic language, and multiply the charms of this pleasing art.

What has formerly been shown to be true in regard to style, will also in many cases hold true of versification, "that it is then *natural* when it is adapted to the *supposed condition* of the speaker."—In the epopee the poet assumes the character of calm inspiration; and therefore his language must be elevated, and his numbers majestic and uniform. A peasant speaking in heroic or hexameter verse is no improbability here; because his words are supposed to be transmitted by one who will of his own accord give them every ornament necessary to reduce them into dignified measure; as an eloquent man, in a solemn assembly, recapitulating the speech of a clown, would naturally express it in pure and perspicuous language. The uniform heroic measure will suit any subject of dignity, whether narrative or didactic, that admits or requires uniformity of style. In tragedy, where the imitation of real life is more perfect than in epic poetry, the uniform magnificence of epic numbers might be improper; because the heroes and heroines are supposed to speak in their own persons, and according to the immediate impulse of passion and sentiment. Yet, even in tragedy, the versification may be both harmonious and dignified; because the characters are taken chiefly from high life, and the events from a remote period; and because the higher poetry is permitted to imitate nature, not as it is, but in that state of perfection in which it might be. The Greeks and Romans considered their hexameter as too artificial for dramatic poetry; and therefore in tragedy, and even in comedy, made use of the iambic, and some other measures that came near the cadence of conversation: we use the iambic both in the epic and dramatic poem; but for the most part it is, or ought to be, much more elaborate in the former than in the latter. In dramatic comedy, where the manners and concerns of familiar life are exhibited, verse would seem to be unnatural, except it be so like the sound of common discourse as to be hardly distinguishable from it. Custom, however, may in some countries determine otherwise; and against custom, in these matters, it is vain to argue. The professed enthusiasm of the dithyrambic poet renders wildness, variety, and a sonorous harmony of numbers, peculiarly suitable to his odes. The love-sonnet, and Anacreontic song, will be less various, more regular, and of a softer harmony; because the state of mind expressed in it has more composure. Philosophy can scarce go further in this investigation, without deviating into whim and hypothesis. The particular sorts of verse to be adopted in the lower species of poetry, are determined by fashion chiefly, and the practice of approved authors.

71
The language of the epic poet must be elevated and his numbers uniformly majestic.

72
In tragedy the same uniform magnificence would be improper, and much more so in comedy.

III. The origin and principles of *imitative harmony*, or of that artifice by which the sound is made, as Pope says, "an echo to the sense," may be explained in the following manner.

It is pleasing to observe the uniformity of nature in all her operations. Between moral and material beauty and harmony, between moral and material deformity and dissonance, there obtains a very striking analogy. The visible and audible expressions of almost every virtuous emotion are agreeable to the eye and the ear, and those of almost every criminal passion disagreeable. The looks, the attitudes, and the vocal sounds, natural to benevolence, to gratitude, to compassion, to piety, are in themselves graceful and pleasing; while anger, discontent, despair, and cruelty, bring discord to the voice, deformity to the features, and distortion to the limbs. That flowing curve, which painters know to be essential to the beauty of animal shape, gives place to a multiplicity

73
A striking analogy between moral and material beauty and deformity.

tiplicity of right lines and ſharp angles in the countenance and geſture of him who knits his brows, ſtretches his noſtrils, grinds his teeth, and clenches his fiſt; whereas, devotion, magnanimity, benevolence, contentment, and good-humour, ſoften the attitude, and give a more graceful ſwell to the outline of every feature. Certain vocal tones accompany certain mental emotions. The voice of ſorrow is feeble and broken, that of deſpair boiſterous and incoherent; joy aſſumes a ſweet and ſprightly note, fear a weak and tremulous cadence; the tones of love and benevolence are muſical and uniform, thoſe of rage loud and diſſonant; the voice of the ſedate reaſoner is equable and grave, but not unpleaſant; and he who declaims with energy, employs many varieties of modulation ſuited to the various emotions that predominate in his diſcourſe.

But it is not in the language of paſſion only that the human voice varies its tone, or the human face its features. Every ſtriking ſentiment, and every intereſting idea, has an effect upon it. One would eſteem that perſon no adept in narrative eloquence, who ſhould deſcribe, with the very ſame accent, ſwift and ſlow motion, extreme labour and eaſy performance, agreeable ſenſation and excruciating pain; who ſhould talk of the tumult of a tempeſtuous ocean, the roar of thunder, the devaſtations of an earthquake, or an Egyptian pyramid tumbling into ruins, in the ſame tone of voice wherewith he deſcribes the murmur of a rill, the warbling of the harp of Æolus, the ſwinging of a cradle, or the deſcent of an angel. Elevation of mind gives dignity to the voice. From Achilles, Sarpedon, and Othello, we ſhould as naturally expect a manly and ſonorous accent, as a nervous ſtyle and majeſtic attitude. Coxcombs and bullies, while they aſſume airs of importance and valour, affect alſo a dignified articulation.

74 The ſource of imitative harmony of numbers.

Since the tones of natural language are ſo various, poetry, which imitates the language of nature, muſt alſo vary its tones; and, in reſpect of ſound as well as of meaning, be framed after that model of ideal perfection, which the variety and energy of the human articulate voice render probable. This is the more eaſily accompliſhed, becauſe in every language there is between the ſound and ſenſe of certain words a perceptible analogy; which, though not ſo accurate as to lead a foreigner from the ſound to the ſignification, is yet accurate enough to ſhow, that, in forming ſuch words, regard has been had to the imitative qualities of vocal ſound. Such, in Engliſh, are the words *yell*, *craſh*, *crack*, *hiſs*, *roar*, *murmur*, and many others.

All the particular laws that regulate this ſort of imitation, as far as they are founded in nature, and liable to the cognizance of philoſophy, depend on the general law of ſtyle above mentioned. Together with the other circumſtances of the ſuppoſed ſpeaker, the poet takes into conſideration the tone of voice ſuitable to the ideas that occupy his mind, and thereto adapts the ſound of his language, if it can be done conſiſtently with eaſe and elegance of expreſſion. But when this imitative harmony is too much ſought after, or words appear to be choſen for ſound rather than ſenſe, the verſe becomes finical and ridiculous. Such is Ronſard's affected imitation of the ſong of the ſky-lark:

> Elle quindée du zephire
> Sublime en l'air vire et revire,
> Et y declique un joli cris,
> Qui rit, guérit, et tire l'ire
> Des eſprit mieux que je n'écris.

This is as ridiculous as that line of Ennius,

> Tum tuba terribili ſonitu taratantara dixit:

Or as the following verſes of Swift;

> The man with the kettle-drum enters the gate,
> Dub dub a dub dub: the trumpeters follow,
> Tantara tantara; while all the boys hollow.

75 What harmony of numbers can imitate.

Words by their ſound may imitate ſound; and quick or ſlow articulation may imitate quick or ſlow motion. Hence, by a proper choice and arrangement of words, the poet may imitate *Sounds* that are ſweet with dignity (H),—ſweet and tender (I),—loud (K),—and harſh (L);—and *Motions* that are ſlow, in conſequence of dignity (M),—ſlow in conſequence of difficulty (N), ſwift

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(H) No ſooner had th' Almighty ceas'd, than all
The multitude of angels, with a ſhout
Loud as from numbers without number, ſweet
As from bleſt voices uttering joy; heav'n rung
With jubilee, and loud hoſannas fill'd
Th' eternal regions.—— *Par. Loſt*, iii.

See alſo the night-ſtorm of thunder, lightning, wind, and rain, in Virg. Georg. lib. i. ver. 328—334.

(I) Et longum, formoſe, vale, vale, inquit, Iola. *Virg.* Ecl. i.

Formoſam reſonare doces Amaryllida ſilvas. *Virg.* Ecl. i.

See alſo the ſimile of the nightingale, Georg. lib. iv. verſ. 511. And ſee that wonderful couplet deſcribing the wailings of the owl, Æneid iv. 462.

(K)————vibratus ab æthere fulgor
Cum ſonitu venit, et ruere omnia viſa repente,
Tyrrhenuſque tubæ mugire per æthera clangor,
Suſpiciunt: iterum atque iterum fragor increpat ingens. *Æneid* viii.

See alſo the ſtorm in the firſt book of the Æneid, and in the fifth of the Odyſſey.

(L) The hoarſe rough verſe ſhould like the torrent roar. *Pope.*

————On a ſudden open fly,
With impetuous recoil and jarring ſound,
Th' infernal doors, and on their hinges grate
Harſh thunder.—— *Par. Loſt*, ii. 879.

See alſo Homer's Iliad, lib. ii. ver. 363, and Clarke's Annotation.

(M) See an exquiſite example in Gray's Progreſs of Poeſy; the concluſion of the third ſtanza.

(N) And when up ten ſteep ſlopes you've dragg'd your thighs. *Pope.*

Juſt brought out this, when ſcarce his tongue could ſtir. *Pope.*

————The huge leviathan
Wallowing unwieldy, enormous in their gait,
Tempeſt the ocean. *Par. Loſt*, vii. 411.

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swift and noisy (O)—swift and smooth (P)—uneven and abrupt (Q),—quick and joyous (R). An unexpected pause in the verse may also imitate a sudden failure of strength (S), or interruption of motion (T), or give vivacity to an image or thought, by fixing our attention longer than usual upon the word that precedes it (U).—Moreover, when we describe great bulk, it is natural for us to articulate slowly, even in common discourse; and therefore a line of poetry that requires a slow pronunciation, or seems longer than it should be, may be used with good effect in describing vastness of size (X).—Sweet and smooth numbers are most proper, when the poet paints agreeable objects, or gentle energy (Y); and harsher sounds when he speaks of what is ugly, violent, or disagreeable (Z). This too is according to the nature of common language; for we generally employ harsher tones of voice to express what we dislike, and more melodious notes to describe the objects of love, complacency, or admiration. Harsh numbers, however, should not be frequent in poetry: for in this art, as in music, concord and melody ought always to predominate. And we find in fact, that good poets can occasionally express themselves somewhat harshly, when the subject requires it, and yet preserve the sweetness and majesty of poetical diction. Further, the voice of complaint, pity, love, and all the gentler affections, is mild and musical, and should therefore be imitated in musical numbers; while despair, defiance, revenge, and turbulent emotions in general, assume an abrupt and sonorous cadence. Dignity of description (A), solemn vows (B), and all sentiments that proceed from a mind elevated with great ideas (C), require a correspon-

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See the famous description of Sisyphus rolling the stone, Odyss. lib. xi. ver. 592. See Quintil. Inst. Orat. lib. ix. cap. 4. § 4. compared with Paradise Lost, book ii. ver. 1022.

(O) Quadrupedante putrem sonitu quatit ungula campum. *Æneid.*

Αυταρ επειτα πεδονδε κυλινδετο λαος αναιδης. *Odyss.* xi.

See also Virg. Æneid. lib. i. ver. 83—87.

(P) See wild as the winds o'er the desert he flies. *Pope.*

Ille volat, simul arva fuga, simul æquora verrens. *Virg.*

Ρηιδιη τ' επειτα πελει, χαλεπη περ εουσα. *Hesiod.*

(Q) Πολλα δ' αναντα καταντα παραντα τε δοχμια τ' ηλθον. *Hom.*

The lass shriek'd, started up, and shriek'd again, *Anonym.*

(R) Let the merry bells ring round,
And the jocund rebecks sound,
To many a youth, and many a maid,
Dancing in the chequer'd shade. *Milt. Allegro.*

See also Gray's Progress of Poesy, stanza 3.

(S) Ac velut in somnis oculos ubi languida pressit
Nocte quies, nequicquam avidos extendere cursus
Velle videmur:—et in mediis conatibus ægri
Succidimus.—— *Æneid.*

See also Virg. Georg. lib. iii. ver. 515, 516.

(T) For this, be sure to-night thou shalt have cramps,
Side-stitches that shall pen thy breath up. Urchins
Shall exercise upon thee.——
Prospero to Calyban in *the Tempest.*

See Pope's Iliad, xiii. 199.

(U) ———How often from the steep
Of echoing hill or thicket have we heard
Celestial voices, to the midnight air,
Sole,—or responsive to each other's note,
Singing their great Creator?——*Par. Lost,* iv.

And over them triumphant Death his dart
Shook,——but delay'd to strike. *Id.*

See also Hom. Odyss. lib. ix. ver. 290.

(X) Thus stretch'd out, huge in length, the arch fiend lay. *Par. Lost.*

Monstrum horrendum, informe, ingens, cui lumen ademptum. *Æneid.* iii.

Et magnos membrorum artus, magna ossa, lacertosque
Exuit, atque ingens media consistit arena.
Æneid. v. 422.

(Y) Hic gelidi fontes, hic mollia prata, Lycori,
Hic nemus, hic ipso tecum consumerer ævo.
Virg. Ecl. x.

The dumb shall sing; the lame his crutch forego,
And leap, exulting, like the bounding roe.
Pope's Messiah.

See Milton's description of the evening, Par. Lost, book iv. ver. 598—609.

Ye gentle gales beneath my body blow,
And softly lay me on the waves below.
Pope's Sappho.

(Z) Stridenti stipula miserum disperdere carmen.
Virg. Ecl. iii.

Immo ego Sardois videar tibi amarior herbis,
Horridior rusco, projecta vilior alga.
Virg. Ecl. vii.

Neu patriæ validas in viscera vertite vires.
Virg. Æneid. vi.

See also Milton's description of the Lazar-house in Paradise Lost, book xi. ver. 477—492.

(A) See Virg. Georg. I. 328. and Homer, Virgil, and Milton, *passim.* See also Dryden's Alexander's Feast, and Gray's Odes.

(B) See Virg. Æneid, iv. 24.

(C) Examples are frequent in the great authors. See Othello's exclamation:

——————O now for ever
Farewell the tranquil mind! &c. *Act* iii. *sc.* 3.

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correspondent pomp of language and versification.— Lastly, an irregular or uncommon movement in the verse may sometimes be of use, to make the reader conceive an image in a particular manner. Virgil, describing horses running over rocky heights at full speed, begins the line with two dactyls, to imitate rapidity, and concludes it with eight long syllables:

> Saxa per, et scopulos, et depressas convalles.
> *Georg.* iii. 276.

which is very unusual measure, but seems well adapted to the thing expressed, namely, to the descent of the animal from the hills to the low ground. At any rate, this extraordinary change of the rhythm may be allowed to bear some resemblance to the animal's change of motion, as it would be felt by a rider, and as we may suppose it is felt by the animal itself.

Other forms of imitative harmony, and many other examples, besides those referred to in the margin, will readily occur to all who are conversant in the writings of the best versifiers, particularly Homer, Virgil, Milton, Lucretius, Spenser, Dryden, Shakespeare, Pope, and Gray.

Part II. Of the DIFFERENT SPECIES of POETRY, with their Particular Principles.

Sect. I. *Of Epic and Dramatic Compositions.*

§ 1. *The Epopee and Drama compared.*

Elem of Criticism.

76 In what tragic and epic poetry agree, and in what they differ.

TRAGEDY and the epic differ not in substantials in both the same ends are proposed, viz. instruction and amusement; and in both the same mean is employed, viz. imitation of human actions. They differ only in the manner of imitating; epic poetry employs narration; tragedy represents its facts as passing in our sight: in the former, the poet introduces himself as an historian; in the latter, he presents his actors, and never himself.

This difference, regarding form only, may be thought slight: but the effects it occasions are by no means so; for what we see makes a deeper impression than what we learn from others. A narrative poem is a story told by another: facts and incidents passing upon the stage, come under our own observation; and are beside much enlivened by action and gesture, expressive of many sentiments beyond the reach of language.

A dramatic composition has another property, independent altogether of action; which is, that it makes a deeper impression than narration: in the former, persons express their own sentiments; in the latter, sentiments are related at second-hand. For that reason, Aristotle, the father of critics, lays it down as a rule *, That in an epic poem the author ought to have every opportunity of introducing his actors, and of confining the narrative part within the narrowest bounds. Homer understood perfectly the advantage of this method; and his poems are both of them in a great measure dramatic. Lucan runs to the opposite extreme: and is guilty of a still greater fault, in stuffing his *Pharsalia* with cold and languid reflections, the merit of which he assumes to himself, and deigns not to share with his actors. Nothing can be more injudiciously timed, than a chain of such reflections, which suspend the battle of Pharsalia, after the leaders had made their speeches, and the two armies are ready to engage †.

* *Poet.* chap 25. sect. 6.

† *Lib.* vii. from line 385 to line 460.

77 Tragic and epic poetry pathetic or moral.

Aristotle, from the nature of the fable, divides tragedy into simple and complex: but it is of greater moment, with respect to dramatic as well as epic poetry, to found a distinction upon the different ends attained by such compositions. A poem, whether dramatic or epic, that has nothing in view but to move the passions and to exhibit pictures of virtue and vice, may be distinguished by the name of *pathetic*: but where a story is purposely contrived to illustrate some moral truth, by showing that disorderly passions naturally lead to external misfortunes, such composition may be denominated *moral*. Beside making a deeper impression than can be done by cool reasoning, a moral poem does not fall short of reasoning in affording conviction: the natural connection of vice with misery, and of virtue with happiness, may be illustrated by stating a fact as well as by urging an argument. Let us assume, for example, the following moral truths: That discord among the chiefs renders ineffectual all common measures; and that the consequences of a slightly-founded quarrel, fostered by pride and arrogance, are not less fatal than those of the grossest injury: these truths may be inculcated by the quarrel between Agamemnon and Achilles at the siege of Troy. If facts or circumstances be wanting, such as tend to rouse the turbulent passions, they must be invented; but no accidental nor unaccountable event ought to be admitted; for the necessary or probable connection between vice and misery is not learned from any events but what are naturally occasioned by the characters and passions of the persons represented, acting in such circumstances. A real event, of which we see not the cause, may afford a lesson, upon the presumption that what hath happened may again happen: but this cannot be inferred from a story that is known to be a fiction.

78 The good effects of such compositions.

Many are the good effects of such compositions. A pathetic composition, whether epic or dramatic, tends to a habit of virtue, by exciting us to do what is right, and restraining us from what is wrong. Its frequent pictures of human woes produce, beside, two effects, extremely salutary: They improve our sympathy, and fortify us to bear our misfortunes. A moral composition must obviously produce the same good effects because by being moral it ceaseth not to be pathetic: it enjoys besides an excellence peculiar to itself; for it not only improves the heart, as above-mentioned, but instructs the head by the moral it contains. It seems impossible to imagine any entertainment more suited to a rational being, than a work thus happily illustrating some moral truth; where a number of persons of different characters are engaged in an important action, some retarding, others promoting, the great catastrophe; and where there is dignity of style as well as of matter. A work of this kind has our sympathy at command,

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mand, and can put in motion the whole train of the social affections: our curiosity in some scenes is excited, in others gratified; and our delight is consummated at the close, upon finding, from the characters and situations exhibited at the commencement, that every incident down to the final catastrophe is natural, and that the whole in conjunction make a regular chain of causes and effects.

Considering that an epic and a dramatic poem are the same in substance, and have the same aim or end, one will readily imagine, that subjects proper for the one must be equally proper for the other. But considering their difference as to form, there will be found reason to correct that conjecture, at least in some degree.

79 The same subjects not always fit for tragic and epic poetry.

Many subjects may indeed be treated with equal advantage in either form: but the subjects are still more numerous for which they are not equally qualified; and there are subjects proper for the one and not at all for the other. To give some slight notion of the difference, as there is no room here for enlarging upon every article, we observe, that dialogue is better qualified for expressing sentiments, and narrative for displaying facts. Heroism, magnanimity, undaunted courage, and other elevated virtues, figure best in action: tender passions, and the whole tribe of sympathetic affections, figure best in sentiment. It clearly follows, that tender passions are more peculiarly the province of tragedy, grand and heroic actions of epic poetry.

"The epic poem is universally allowed to be *, of all poetical works, the most dignified, and, at the same time, the most difficult in execution. To contrive a story which shall please and interest all readers, by being at once entertaining, important, and instructive; to fill it with suitable incidents; to enliven it with a variety of characters and of descriptions; and, throughout a long work, to maintain that propriety of sentiment, and that elevation of style, which the epic character requires, is unquestionably the highest effort of poetical genius.

* *Blair's Lectures.*

80 The proper subject of an epic poem.

"The action or subject of the epic poem must be great and interesting. Without greatness it would not have sufficient importance either to fix our attention or to justify the magnificent apparatus which the poet bestows on it. This is so evidently requisite as not to require illustration; and, indeed, hardly any who have attempted epic poetry have failed in choosing some subject sufficiently important, either by the nature of the action or by the fame of the personages concerned in it. The fame of Homer's heroes, and the consequences of dissension between the greatest of them, is a subject important in itself, and must have appeared particularly so to his countrymen, who boasted their descent from those heroes. The subject of the Æneid is still greater than that of the Iliad, as it is the foundation of the most powerful empire that ever was established upon this globe; an event of much greater importance than the destruction of a city, or the anger of a semibarbarous warrior. But the poems of Homer and Virgil fall in this respect infinitely short of that of Milton. 'Before the greatness displayed in Paradise Lost, it has been well observed § that all other greatness shrinks away. The subject of the English poet is not the destruction of a city, the conduct of a colony, or the foundation of an empire: it is the fate of worlds, the revolutions of heaven and earth; rebellion against the Supreme King, raised by the highest order of created beings; the overthrow of their host, and the punishment of their crime; the creation of a new race of reasonable creatures; their original happiness and innocence, their forfeiture of immortality, and their restoration to hope and peace."

§ *Johnson's Life of Milton.*

An epic poem, however, is defective if its action be not interesting as well as great; for a narrative of mere valour may be so constructed as to prove cold and tiresome. "Much * will depend on the happy choice of some subject, which shall by its nature interest the public; as when the poet selects for his hero one who is the founder, or the deliverer, or the favourite of his nation; or when he writes atchievements that have been highly celebrated, or have been connected with important consequences to any public cause. Most of the great epic poems are abundantly fortunate in this respect, and must have been very interesting to those ages in which they were composed." The subject of the Paradise Lost, as it is infinitely greater, must likewise be considered as more universally interesting than that of any other poem. "We all feel the effects of Adam's transgression; we all sin like him, and like him must all bewail our offences. We have restless and insidious enemies in the fallen angels, and in the blessed spirits we have guardians and friends; in the redemption of mankind we hope to be included; in the description of heaven and hell we are surely interested, as we are all to reside hereafter either in the regions of horror or bliss."

* *Blair* ubi supra.

81 Circumstances chiefly interesting in epic poetry.

"The chief circumstance which renders an epic poem interesting †, and which tends to interest not one age or country alone, but all readers, is the skilful conduct of the author in the management of his subject. His plan must comprehend many affecting incidents. He may sometimes be awful and august; he must often be tender and pathetic; he must give us gentle and pleasing scenes of love, friendship, and affection. The more that an epic poem abounds with situations which awaken the feelings of humanity, it is the more interesting. In this respect perhaps no epic poets have been so happy as Virgil and Tasso. The plan of the *Paradise Lost* comprises neither human actions nor human manners. The man and woman who act and suffer, are in a state which no other man or woman can ever know. The reader finds no transaction in which he can be engaged; beholds no condition in which he can by any effort of imagination place himself; he has therefore little natural curiosity or sympathy."

† *Blair and Johnson.*

82 Whether the hero must necessarily be successful.

A question has been moved, Whether the nature of the epic poem does not require that the hero should be ultimately successful? To this question Johnson replies, that "there is no reason why the hero should not be unfortunate, except established practice, since success and virtue do not necessarily go together." Most critics, however, are of a different opinion, and hold success to be, if not the necessary, at least the most proper issue of an epic poem. An unhappy conclusion depresses the mind, and is opposite to the elevating emotions which belong to this species of poetry. Terror and compassion are the proper subjects of tragedy; but as the epic is of larger extent, it were too much, if, after the difficulties and troubles which commonly abound in the progress of the poem, the author should bring them all at last to an unfortunate conclusion. We know not that any author of name has held this course except *Lucan;* for in the *Paradise Lost*, as Adam's deceiver is at last crushed, and he himself restored to the favour of his maker, Milton's hero must be considered as finally successful.

4

We

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We have no occasion to say more of the epic, considered as peculiarly adapted to certain subjects, and to be conducted according to a certain plan. But as dramatic subjects are more complex, it is necessary to take a narrower view of them. They are either the light and the gay, or the grave and affecting, incidents of human life. The former constitute the subject of comedy, and the latter of tragedy.

As great and serious objects command more attention than little and ludicrous ones; as the fall of a hero interests the public more than the marriage of a private person; tragedy has been always held a more dignified entertainment than comedy. The first thing required of the tragic poet is, that he pitch upon some moving and interesting story, and that he conduct it in a natural and probable manner. For we must observe, that the natural and probable are more essential to tragic than even to epic poetry. Admiration is excited by the wonderful; but passion can be raised only by the impressions of nature and truth upon the mind.

84
Subjects best suited to tragedy.

The subject best fitted for tragedy is where a man has himself been the cause of his misfortune; not so as to be deeply guilty, nor altogether innocent: the misfortune must be occasioned by a fault incident to human nature, and therefore in some degree venial. Such misfortunes call forth the social affections, and warmly interest the spectator. An accidental misfortune, if not extremely singular, doth not greatly move our pity: the person who suffers, being innocent, is freed from the greatest of all torments, that anguish of mind which is occasioned by remorse. An atrocious criminal, on the other hand, who brings misfortunes upon himself, excites little pity, for a different reason: his remorse, it is true, aggravates his distress, and swells the first emotions of pity: but then our hatred of him as a criminal blending with pity, blunts its edge considerably. Misfortunes that are not innocent, nor highly criminal, partake the advantages of each extreme: they are attended with remorse to embitter the distress, which raises our pity to a great height; and the slight indignation we have at a venial fault detracts not sensibly from our pity. The happiest of all subjects accordingly for raising pity, is where a man of integrity falls into a great misfortune by doing an action that is innocent, but which, by some singular means, is conceived by him to be criminal: his remorse aggravates his distress; and our compassion, unrestrained by indignation, knows no bounds. Pity comes thus to be the ruling passion of a pathetic tragedy; and, by proper representation, may be raised to a height scarcely exceeded by any thing felt in real life. A moral tragedy takes in a larger field; as it not only exercises our pity, but raises another passion, which, though selfish, deserves to be cherished equally with the social affection. The passion we have in view is fear or terror; for when a misfortune is the natural consequence of some wrong bias in the temper, every spectator who is conscious of such a bias in himself takes the alarm, and dreads his falling into the same misfortune: and by the emotion of fear or terror, frequently reiterated in a variety of moral tragedies, the spectators are put upon their guard against the disorders of passion.

The commentators upon Aristotle, and other critics, have been much gravelled about the account given of tragedy by that author: "That by means of pity and terror, it refines or purifies in us all sorts of passion." But no one who has a clear conception of the end and effects of a good tragedy, can have any difficulty about Aristotle's meaning: Our pity is engaged for the persons represented; and our terror is upon our own account. Pity indeed is here made to stand for all the sympathetic emotions, because of these it is the capital. There can be no doubt, that our sympathetic emotions are refined or improved by daily exercise; and in what manner our other passions are refined by terror, has been just now said. One thing is certain, that no other meaning can justly be given to the foregoing doctrine than that now mentioned; and that it was really Aristotle's meaning, appears from his 13th chapter, where he delivers several propositions conformable to the doctrine as here explained. These, at the same time, we take liberty to mention; because, so far as authority can go, they confirm the foregoing reasoning about subjects proper for tragedy. The first proposition is, That it being the province of tragedy to excite pity and terror, an innocent person falling into adversity ought never to be the subject. This proposition is a necessary consequence of his doctrine as explained; a subject of that nature may indeed excite pity and terror; but the former in an inferior degree, and the latter in no degree for moral instruction. The second proposition is, That the history of a wicked person in a change from misery to happiness ought not to be represented; which excites neither terror nor compassion, nor is agreeable in any respect. The third is, That the misfortunes of a wicked person ought not to be represented: such representation may be agreeable in some measure upon a principle of justice; but it will not move our pity, or any degree of terror, except in those of the same vicious disposition with the person represented. The last proposition is, That the only character fit for representation lies in the middle, neither eminently good nor eminently bad; where the misfortune is not the effect of deliberate vice, but of some involuntary fault, as our author expresses it. The only objection we find to Aristotle's account of tragedy, is, that he confines it within too narrow bounds, by refusing admittance to the pathetic kind: for if terror be essential to tragedy, no representation deserves that name but the moral kind, where the misfortunes exhibited are caused by a wrong balance of mind, or some disorder in the internal constitution: such misfortunes always suggest moral instruction; and by such misfortunes only can terror be excited for our improvement.

Thus Aristotle's four propositions above-mentioned relate solely to tragedies of the moral kind. Those of the pathetic kind are not confined within so narrow limits: subjects fitted for the theatre are not in such plenty as to make us reject innocent misfortunes which rouse our sympathy, though they inculcate no moral. With respect indeed to the subjects of that kind, it may be doubted, whether the conclusion ought not always to be fortunate. Where a person of integrity is represented as suffering to the end under misfortunes purely accidental, we depart discontented, and with some obscure sense of injustice: for seldom is man so submissive to Providence, as not to revolt against the tyranny and vexations of blind chance; he will be tempted to say, this ought not to be. We give for an example the *Romeo and Juliet* of Shakespeare, where the fatal catastrophe is occasioned by Friar Lawrence's coming to the monument a minute too late; we are vexed at the unlucky chance, and go away dissatisfied. Such impressions,

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sions, which ought not to be cherished, are a sufficient reason for excluding stories of this kind from the theatre.

85
The improper use of destiny in the ancient tragedies.

The misfortunes of a virtuous person, arising from necessary causes, or a chain of unavoidable circumstances, as they excite a notion of destiny, are equally unsatisfactory to the human mind. A metaphysician in his closet may reason himself into the belief of fate, or what in modern language is called *philosophical necessity*; but the feelings of the heart revolt against that doctrine; and we have the confession of the two ablest philosophers by whom it was ever maintained, that men conduct themselves through life as if their will were absolutely free, and their actions no part of a chain of necessary causes and effects. As no man goes to the theatre to study metaphysics, or to divest himself of the common feelings of humanity, it is impossible, whatever be his philosophical creed, that he should contemplate without horror and disgust an innocent person suffering by mere destiny. A tragedy of uncommon merit in every other respect may indeed be endured, nay perhaps admired, though such be its catastrophe; because no work of man was ever perfect; and because, where imperfections are unavoidable, a multitude of excellencies may be allowed to cover one fault: but we believe the misery of an innocent person resulting from a chain of unavoidable circumstances has never been considered as a beauty by minds unperverted by a false philosophy. "It must be acknowledged * that the subjects of the ancient Greek tragedies were frequently founded on mere destiny and inevitable misfortunes. In the course of the drama many moral sentiments occurred; but the only instruction which the fable conveyed was, that reverence was due to the gods, and submission to the decrees of fate. Modern tragedy has aimed at a higher object, by becoming more the theatre of passion; pointing out to men the consequences of their own misconduct, showing the direful effects which ambition, jealousy, love, resentment, and other such strong emotions, when misguided or left unrestrained, produce upon human life. An Othello, hurried by jealousy to murder his innocent wife; a Jaffier ensnared by resentment and want to engage in a conspiracy, and then stung with remorse and involved in ruin; a Siffredi, through the deceit which he employs for public-spirited ends, bringing destruction on all whom he loved: these, and such as these, are the examples which Tragedy now displays to public view; and by means of which it inculcates on men the proper government of their passions."

* Blair.

86
How it is used in the tragedy of the Robbers.

There is indeed one singular drama, in which destiny is employed in a manner very different from that in which it was used by the poets of Greece and Rome. It is Schiller's tragedy of the Robbers, of which "the hero endowed by nature (as the translator of the piece observes) with the most generous feelings, animated by the highest sense of honour, and susceptible of the warmest affections of the heart, is driven by the perfidy of a brother, and the supposed inhumanity of his father, into a state of confirmed misanthropy and despair." He wishes that he "could blow the trumpet of rebellion through all nature; that he could extinguish with one mortal blow the viperous race of men; and that he could so strike as to destroy the germ of existence." In this situation he is hurried on to the perpetration of a series of crimes which find from their very magnitude and atrocity a recommendation to his distempered mind. Sensible all the while of his own guilt, and suffering for that guilt the severest pangs of remorse, he yet believes himself an instrument of vengeance in the hands of the Almighty for the punishment of the crimes of others. In thus accomplishing the dreadful destiny which is prescribed for him, he feels a species of gloomy satisfaction, at the same time that he considers himself as doomed to the performance of that part in life which is to consign his memory to infamy and his soul to perdition. After burning a town, he exclaims, "O God of vengeance! am I to blame for this? Art thou to blame, O Father of Heaven! when the instruments of thy wrath, the pestilence, flood, and famine overwhelm at once the righteous and the guilty? Who can command the flames to stay their course, to destroy only the noxious vermin, and spare the fertile field?" yet with the same breath he acuses himself of extreme criminality for "presumptuously wielding the sword of the Most High!" He frequently laments in the most affecting manner the loss of his innocence, wishes that "he could return into the womb that bare him, that he hung an infant at the breast, that he were born a beggar, the meanest hind, a peasant of the field." He considers himself as the outcast of Heaven, and finally rejected by the Father of mercy; yet he tells the band of robbers whom he commanded, that the "Almighty honoured them as agents in his hands to execute his wonderous purposes; employed them as his angels to execute his stern decrees, and pour the vials of his wrath;" and in a very solemn prayer, he supposes that "the God who ruleth over all had *decreed* that he should become the chief of these foul murderers."

"It will be allowed, (says the translator), that the imagination could not have conceived a spectacle more deeply interesting, more powerfully affecting to the mind of man, than that of a human being thus characterised and acting under such impressions. The compassionate interest which the mind feels in the emotions or sufferings of the guilty person, is not diminished by the observation, that he acts under an impression of inevitable destiny; on the contrary, there is something in our nature which leads us the more to compassionate the instrument of those crimes, that we see him consider himself as bound to guilt by fetters, which he has the constant wish, but not the strength, to break."

This is indeed true: we sympathise with the hero of the Robbers, not only on account of his exalted sentiments and his inflexible regard to the abstract principles of honour and justice, but much more for that disorder of intellect which makes him *suppose* "his destiny fixed and unalterable," at the very time that he is torn with remorse for the perpetration of those crimes by which he believed it to be fulfilling. Destiny, however, is not in this tragedy exhibited as real, but merely as the phantom of a distempered though noble mind. Had the poet represented his hero as in *fact decreed by God*, or *bound by fate*, to head a band of foul murderers, and to commit a series of the most atrocious crimes; though our pity for him might not have been lessened, the impressions of the whole piece on the mind could have been only those of horror and disgust at what would have appeared to us the unequal ways of providence.

The Tragedy of the Robbers is a striking instance of the justness of Dr Blair's criticism, in opposition to that of

Of the Epopee and Drama.

of Lord Kames. His lordſhip holds that it is eſſential to a good tragedy, that its principal facts be borrowed from hiſtory; becauſe a mixture of known truth with the fable tends to delude us into a conviction of the reality of the whole. The Doctor conſiders this as a matter of no great conſequence; for "it is proved by experience, that a fictitious tale, if properly conducted, will melt the heart as much as any real hiſtory;" this obſervation is verified in the Robbers. It is indeed a very irregular drama, and perhaps could not be acted on a Britiſh theatre. But although the whole is known to be a fiction, we believe there are few effuſions of human genius which more powerfully excite the emotions of terror and pity. Truth is indeed congenial to the mind; and when a ſubject proper for tragedy occurs in hiſtory or tradition, it is perhaps better to adopt it than to invent one which has no ſuch foundation. But in chooſing a ſubject which makes a figure in hiſtory, greater precaution is neceſſary than where the whole is a fiction. In the latter caſe, the author is under no reſtraint other than that the characters and incidents be juſt copies of nature. But where the ſtory is founded on truth, no circumſtances muſt be added, but ſuch as connect naturally with what are known to be true; hiſtory may be ſupplied, but muſt not be contradicted. Further, the ſubject choſen muſt be diſtant in time, or at leaſt in place; for the familiarity of recent perſons and events ought to be avoided. Familiarity ought more eſpecially to be avoided in an epic poem, the peculiar character of which is dignity and elevation: modern manners make but a poor figure in ſuch a poem. Their familiarity unqualifies them for a lofty ſubject. The dignity of them will be better underſtood in future ages, when they are no longer familiar.

87 Whether the ſubject of tragedy ſhould have its foundation in truth.

After Voltaire, no writer, it is probable, will think of rearing an epic poem upon a recent event in the hiſtory of his own country. But an event of that kind is perhaps not altogether unqualified for tragedy: it was admitted in Greece; and Shakeſpeare has employed it ſucceſsfully in ſeveral of his pieces. One advantage it poſſeſſes above fiction, that of more readily engaging our belief, which tends above any other particular to raiſe our ſympathy. The ſcene of comedy is generally laid at home: familiarity is no objection; and we are peculiarly ſenſible of the ridicule of our own manners.

88 How a tragedy ſhould be divided into acts; and how many acts it ſhould have.

Elem. of Criticiſm, ch. xxii.

After a proper ſubject is choſen, the dividing it into parts requires ſome art. The concluſion of a book in an epic poem, or of an act in a play, cannot be altogether arbitrary; nor be intended for ſo ſlight a purpoſe as to make the parts of equal length. The ſuppoſed pauſe at the end of every book, and the real pauſe at the end of every act, ought always to coincide with ſome pauſe in the action. In this reſpect, a dramatic or epic poem ought to reſemble a ſentence or period in language, divided into members that are diſtinguiſhed from each other by proper pauſes; or it ought to reſemble a piece of muſic, having a full cloſe at the end, preceded by imperfect cloſes that contribute to the melody. The diviſion of every play into *five* acts has no other foundation than common practice, and the authority of Horace (D). It is a diviſion purely arbitrary; there is nothing in the nature of the compoſition which fixes this number rather than any other; and it had been much better if no ſuch number had been aſcertained. But, ſince it is aſcertained, every act in a dramatic poem ought to cloſe with ſome incident that makes a pauſe in the action; for otherwiſe there can be no pretext for interrupting the repreſentation. It would be abſurd to break off in the very heat of action; againſt which every one would exclaim: the abſurdity ſtill remains where the action relents, if it be not actually ſuſpended for ſome time. This rule is alſo applicable to an epic poem: though in it a deviation from the rule is leſs remarkable; becauſe it is in the reader's power to hide the abſurdity, by proceeding inſtantly to another book. The firſt book of Paradiſe Loſt ends without any cloſe, perfect or imperfect: it breaks off abruptly, where Satan, ſeated on his throne, is prepared to harangue the convocated hoſt of the fallen angels; and the ſecond book begins with the ſpeech. Milton ſeems to have copied the Æneid, of which the two firſt books are divided much in the ſame manner. Neither is there any proper pauſe at the end of the ſeventh book of Paradiſe Loſt, nor at the end of the eleventh. In the Iliad little attention is given to this rule.

89 The object of comedy.

Beſides tragedy, dramatic poetry comprehends comedy and farce. Theſe are ſufficiently diſtinguiſhed from tragedy by their general ſpirit and ſtrain. "While pity and terror, and the other ſtrong paſſions, form the province of the tragic muſe, the chief or rather ſole inſtrument of comedy and farce is ridicule." Theſe two ſpecies of compoſition are ſo perpetually running into each other, that we ſhall not treat of them ſeparately; ſince what is now known by the name of *farce* differs in nothing eſſential from what was called the *old comedy* among the Greeks. "Comedy propoſes for its object * neither the great ſufferings nor the great crimes of men; but their follies and ſlighter vices, thoſe parts of their character which raiſe in beholders a ſenſe of impropriety, which expoſe them to be cenſured and laughed at by others, or which render them troubleſome in civil ſociety.

* *Blair's Lectures.*

"The ſubjects of tragedy are not limited to any age or country; but the ſcene and ſubject of comedy ſhould always be laid in our own country, and in our own times. The reaſon is obvious: thoſe decorums of behaviour, thoſe leſſer diſcriminations of character, which afford ſubject for comedy, change with the differences of countries and times; and can never be ſo well underſtood by foreigners as by natives. The comic poet, who aims at correcting improprieties and follies of behaviour, ſhould 'catch the manners living as they riſe.' It is not his buſineſs to amuſe us with a tale of other times; but to give us pictures taken from among ourſelves; to ſatirize

(D) *Neve minor, neu ſit quinto productior actu*
Fabula. De Arte Poetica.

If you would have your play deſerve ſucceſs,
Give it five acts complete, nor more nor leſs. Francis.

reigning and present vices; to exhibit to the age a faithful copy of itself, with its humours, its follies, and its extravagancies.

90 Comedy of two kinds.

"Comedy may be divided into two kinds: comedy of *character*, and comedy of *intrigue*. The former is the more valuable species; because it is the business of comedy to exhibit the prevailing manners which mark the character of the age in which the scene is laid: yet there should be always as much intrigue as to give us something to wish and something to fear. The incidents should so succeed one another, as to produce striking situations, and to fix our attention; while they afford at the same time a proper field for the exhibition of character. The action in comedy, though it demands the poet's care in order to render it animated and natural, is a less significant and important part of the performance than the action in tragedy: as in comedy it is what men say, and how they behave, that draws our attention, rather than what they perform or what they suffer.

91 The common faults of comedy.

"In the management of characters, one of the most common faults of comic writers is the carrying of them too far beyond life. Wherever ridicule is concerned, it is indeed extremely difficult to hit the precise point where true wit ends and buffoonery begins. When the miser in Plautus, searching the person whom he suspects of having stolen his casket, after examining first his right hand and then his left, cries out, *ostende etiam tertiam*—'show me your third hand,' there is no one but must be sensible of the extravagance. Certain degrees of exaggeration are allowed to the comedian, but there are limits set to it by nature and good taste; and supposing the miser to be ever so much engrossed by his jealousy and his suspicions, it is impossible to conceive any man in his wits suspecting another of having more than two hands."

It appears from the plays of Aristophanes which remain, that the characters in the old comedy of Athens were almost always overcharged. They were likewise direct and avowed satires against particular persons, who were brought upon the stage by name. "The ridicule employed in them is extravagant, the wit for the most part buffoonish and farcical, the raillery biting and cruel, and the obscenity that reigns in them is gross and intolerable. They seem to have been composed merely for the mob." Yet of these abominable dramas, an excellent critic * has affirmed, with too much truth, that what is now called *farce* is nothing more than the shadow. The characters in genuine comedy are not those of particular and known persons, but the general characters of the age and nation; which it requires no small skill to distinguish clearly and naturally from each other. In attempting this, poets are too apt to contrast characters and introduce them always in pairs; which gives an affected air to the whole piece. The perfection of art is to conceal art. "A masterly writer will give us his characters distinguished rather by such shades of diversity as are commonly found in society, than marked with such strong oppositions as are rarely brought into actual contrast in any of the circumstances of real life."

* *Hurd.*

92 The style of comedy.

The style of comedy ought to be pure, elegant, and lively, very seldom rising higher than the ordinary tone of polite conversation; and upon no occasion descending into vulgar, mean, and gross expressions; and in one word, action and character being the fundamental parts of every epic and dramatic composition, the sentiments and tone of language ought to be subservient to these, so as to appear natural and proper for the occasion.

§ 2. *Respective peculiarities of the Epopee and Drama.*

93 Machinery can have no place in a drama, nor

In a theatrical entertainment, which employs both the eye and the ear, it would be a gross absurdity to introduce upon the stage superior beings in a visible shape. There is no place for such objection in an *epic poem*; and Boileau, with many other critics, declares strongly for that sort of machinery in an epic poem. But waving authority, which is apt to impose upon the judgement, let us draw what light we can from reason. We may in the first place observe, that this matter is but indistinctly handled by critics: the poetical privilege of animating insensible objects for enlivening a description, is very different from what is termed *machinery*, where deities, angels, devils, or other supernatural powers, are introduced as real personages, mixing in the action, and contributing to the catastrophe; and yet these two things are constantly jumbled together in reasoning. The former is founded on a natural principle: but nothing is more unnatural than the latter. Its effects, at the same time, are deplorable. First, it gives an air of fiction to the whole; and prevents that impression of reality which is requisite to interest our affections, and to move our passions; which of itself is sufficient to explode machinery, whatever entertainment it may afford to readers of a fantastic taste or irregular imagination.

94 has it a good effect in the higher epic.

And, next, were it possible, by disguising the fiction, to delude us into a notion of reality, an insuperable objection would still remain, which is, that the aim or end of an epic poem can never be attained in any perfection where machinery is introduced; for an evident reason, that virtuous emotions cannot be raised successfully but by the actions of those who are endued with passions and affections like our own, that is, by human actions; and as for moral instruction, it is clear, that none can be drawn from beings who act not upon the same principles with us. A fable in Æsop's manner is no objection to this reasoning: his lions, bulls, and goats, are truly men under disguise; they act and feel in every respect as human beings; and the moral we draw is founded on that supposition. Homer, it is true, introduces the gods into his fable: but the religion of his country authorized that liberty; it being an article in the Grecian creed, that the gods often interpose visibly and bodily in human affairs. It must however be observed, that Homer's deities do no honour to his poems: fictions that trangress the bounds of nature, seldom have a good effect; they may inflame the imagination for a moment, but will not be relished by any person of a correct taste. They may be of some use to the lower rank of writers; but an author of genius has much finer materials, of Nature's production, for elevating his subject, and making it interesting.

One would be apt to think, that Boileau, declaring for the Heathen deities, intended them only for embellishing the diction: but unluckily he banishes angels and devils, who undoubtedly make a figure in poetic language, equal to the Heathen deities. Boileau, therefore, by pleading for the latter in opposition to the former, certainly meant, if he had any distinct meaning, that the Heathen deities may be introduced as actors. And, in fact, he himself is guilty of that glaring absurdity, where

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where it is not so pardonable as in an epic poem: In his ode upon the taking of Namur, he demands with a most serious countenance, whether the walls were built by Apollo or Neptune: and in relating the passage of the Rhine, anno 1672, he describes the god of that river as fighting with all his might to oppose the French monarch; which is confounding fiction with reality at a strange rate. The French writers in general run into this error: wonderful the effect of custom, entirely to hide from them how ridiculous such fictions are.

That this is a capital error in *Gierusalemme Liberata*, Tasso's greatest admirers must acknowledge: a situation can never be intricate, nor the reader even in pain about the catastrophe, so long as there is an angel, devil, or magician, to lend a helping hand. Voltaire, in his essay upon epic poetry, talking of the *Pharsalia*, observes judiciously, "That the proximity of time, the notoriety of events, the character of the age, enlightened and political, joined with the solidity of Lucan's subject, deprived him of poetical fiction." Is it not amazing, that a critic who reasons so justly with respect to others, can be so blind with respect to himself? Voltaire, not satisfied to enrich his language with images drawn from invisible and superior beings, introduces them into the action: in the sixth canto of the *Henriade*, St Louis appears in person, and terrifies the soldiers; in the seventh canto, St Louis sends the god of Sleep to Henry; and, in the tenth, the Demons of Discord, Fanaticism, War, &c. assist Aumale in a single combat with Turenne, and are driven away by a good angel brandishing the sword of God. To blend such fictitious personages in the same action with mortals, makes a bad figure at any rate; and is intolerable in a history so recent as that of Henry IV. But perfection is not the lot of man.

But perhaps the most successful weapon that can be employed upon this subject is ridicule. Addison has applied this in an elegant manner: "Whereas the time of a general peace is, in all appearance, drawing near; being informed that there are several ingenious persons who intend to show their talents on so happy an occasion, and being willing, as much as in me lies, to prevent that effusion of nonsense which we have good cause to apprehend; I do hereby strictly require every person who shall write on this subject, to remember that he is a Christian, and not to sacrifice his catechism to his poetry. In order to it, I do expect of him, in the first place, to make his own poem, without depending upon Phœbus for any part of it, or calling out for aid upon any of the Muses by name. I do likewise positively forbid the sending of Mercury with any particular message or dispatch relating to the peace; and shall by no means suffer Minerva to take upon her the shape of any plenipotentiary concerned in this great work. I do further declare, that I shall not allow the Destinies to have had a hand in the deaths of the several thousands who have been slain in the late war; being of opinion that all such deaths may be well accounted for by the Christian system of powder and ball. I do therefore strictly forbid the Fates to cut the thread of man's life upon any pretence whatsoever, unless it be for the sake of rhyme. And whereas I have good reason to fear, that Neptune will have a great deal of business on his hands in several poems which we may now suppose are upon the anvil, I do also prohibit his appearance, unless it be done in metaphor, simile, or any very short allusion; and that even here he may not be permitted to enter, but with great caution and circumspection. I desire that the same rule may be extended to his whole fraternity of Heathen gods; it being my design to condemn every poem to the flames in which Jupiter thunders, or exercises any other act of authority which does not belong to him. In short, I expect that no pagan agent shall be introduced, or any fact related which a man cannot give credit to with a good conscience. Provided always, that nothing herein contained shall extend, or be construed to extend to several of the female poets in this nation, who shall still be left in full possession of their gods and goddesses, in the same manner as if this paper had never been written." *Spect.* N° 523.

The marvellous is indeed so much promoted by machinery, that it is not wonderful to find it embraced by the bulk of writers, and perhaps of readers. If indulged at all, it is generally indulged to excess. Homer introduceth his deities with no greater ceremony than his mortals; and Virgil has still less moderation: a pilot spent with watching cannot fall asleep and drop into the sea by natural means: one bed cannot receive the two lovers Æneas and Dido, without the immediate interposition of superior powers. The ridiculous in such fictions must appear even through the thickest veil of gravity and solemnity.

Angels and devils serve equally with Heathen deities as materials for figurative language; perhaps better among Christians, because we believe in them, and not in Heathen deities. But every one is sensible, as well as Boileau, that the invisible powers in our creed make a much worse figure as actors in a modern poem than the invisible powers in the Heathen creed did in ancient poems; the cause of which is not far to seek. The Heathen deities, in the opinion of their votaries, were beings elevated one step only above mankind, subject to the same passions, and directed by the same motives; therefore not altogether improper to mix with men in an important action. In our creed, superior beings are placed at such a mighty distance from us, and are of a nature so different, that with no propriety can we appear with them upon the same stage: man, a creature much inferior, loses all dignity in the comparison.

95

An historical poem admits of allegory, &c. under proper restrictions.

There can be no doubt that an historical poem admits the embellishment of allegory as well as of metaphor, simile, or other figure. Moral truth, in particular, is finely illustrated in the allegorical manner: it amuses the fancy to find abstract terms, by a sort of magic, metamorphosed into active beings; and it is delightful to trace a general proposition in a pictured event. But allegorical beings should be confined within their own sphere, and never be admitted to mix in the principal action, nor to co-operate in retarding or advancing the catastrophe; which would have a still worse effect than invisible powers: for the impression of real existence, essential to an epic poem, is inconsistent with that figurative existence which is essential to an allegory; and therefore no method can more effectually prevent the impression of reality than the introduction of allegorical beings co-operating with those whom we conceive to be really existing. The love-episode in the Henriade (canto 9.), insufferable by the discordant mixture of allegory with real life, is copied from that of Rinaldo and Armida in the *Gierusalemme Liberata*, which hath no merit

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merit to entitle it to be copied. An allegorical object, ſuch as Fame in the Æneid, and the Temple of Love in the Henriade, may find place in a deſcription: but to introduce Diſcord as a real perſonage, imploring the aſſiſtance of Love as another real perſonage, to enervate the courage of the hero, is making theſe figurative beings act beyond their ſphere, and creating a ſtrange jumble of truth and fiction. The allegory of Sin and Death in the Paradiſe Loſt is poſſibly not generally reliſhed. though it is not entirely of the ſame nature with what we have been condemning; in a work comprehending the atchievements of ſuperior beings there is more room for fancy than where it is confined to human actions.

What is the true notion of an epiſode? or how is it to be diſtinguiſhed from the principal action? Every incident that promotes or retards the cataſtrophe muſt be part of the principal action. This clears the nature of an epiſode; which may be defined, "An incident connected with the principal action, but contributing neither to advance nor retard it." The deſcent of Æneas into hell does not advance or retard the cataſtrophe, and therefore is an epiſode. The ſtory of Niſus and Euryalus, producing an alteration in the affairs of the contending parties, is a part of the principal action. The family-ſcene in the ſixth book of the Iliad is of the ſame nature; for by Hector's retiring from the field of battle to viſit his wife, the Grecians had opportunity to breathe, and even to turn upon the Trojans. The unavoidable effect of an epiſode according to this definition muſt be, to break the unity of action; and therefore it ought never to be indulged unleſs to unbend the mind after the fatigue of a long narration. An epiſode, when ſuch is its purpoſe, requires the following conditions: it ought to be well connected with the principal action; it ought to be lively and intereſting; it ought to be ſhort; and a time ought to be choſen when the principal action relents (E).

96 Epiſode defined.

97 What conſtitutes a good epiſode.

In the following beautiful epiſode, which cloſes the ſecond book of Fingal, all theſe conditions are united.

"Comal was a ſon of Albion; the chief of an hundred hills. His deer drunk of a thouſand ſtreams; and a thouſand rocks replied to the voice of his dogs. His face was the mildneſs of youth; but his hand the death of heroes. One was his love, and fair was ſhe! the daughter of mighty Conloch. She appeared like a ſunbeam among women, and her hair was like the wing of the raven. Her ſoul was fixed on Comal, and ſhe was his companion in the chace. Often met their eyes of love, and happy were their words in ſecret. But Gormal loved the maid, the chief of gloomy Ardven. He watched her lone ſteps on the heath, the foe of unhappy Comal.

"One day, tired of the chace, when the miſt had concealed their friends, Comal and the daughter of Conloch met in the cave of Ronan. It was the wonted haunt of Comal. Its ſides were hung with his arms; a hundred ſhields of thongs were there, a hundred helms of ſounding ſteel. Reſt here, ſaid he, my love Galvina, thou light of the cave of Ronan: a deer appears on Mora's brow; I go, but ſoon will return. I fear, ſaid ſhe, dark Gormal my foe: I will reſt here; but ſoon return, my love.

"He went to the deer of Mora. The daughter of Conloch, to try his love, clothed her white ſide with his armour, and ſtrode from the cave of Ronan. Thinking her his foe, his heart beat high, and his colour changed. He drew the bow: the arrow flew: Galvina fell in blood. He ran to the cave with haſty ſteps, and called the daughter of Conloch. Where art thou, my love? but no anſwer.——He marked, at length, her heaving heart beating againſt the mortal arrow. O Conloch's daughter, is it thou!—he ſunk upon her breaſt.

"The hunters found the hapleſs pair. Many and ſilent were his ſteps round the dark dwellings of his love. The fleet of the ocean came: he fought, and the ſtrangers fell: he ſearched for death over the field; but who could kill the mighty Comal? Throwing away his ſhield, an arrow found his manly breaſt. He ſleeps with his Galvina: their green tombs are ſeen by the mariner when he bounds on the waves of the north."

Next, upon the peculiarities of a *dramatic poem*. And the firſt we ſhall mention is a double plot: one of which muſt reſemble an epiſode in an epic poem; for it would diſtract the ſpectator, inſtead of entertaining him, if he were forced to attend at the ſame time to two capital plots equally intereſting. And even ſuppoſing it an under-plot like an epiſode, it ſeldom hath a good effect in tragedy, of which ſimplicity is a chief property; for an intereſting ſubject that engages our affections, occupies our whole attention, and leaves no room for any ſeparate concern. Variety is more tolerable in comedy; which pretends only to amuſe, without totally occupying the mind. But even there, to make a double plot agreeable, is no ſlight effort of art: the under plot ought not to vary greatly in its tone from the principal; for diſcordant emotions are unpleaſant when jumbled together; which, by the way, is an inſuperable objection to tragi-comedy. Upon that account the Provok'd Huſband deſerves cenſure; all the ſcenes that bring the family of the Wrongheads into action, being ludicrous and farcical, are in a very different tone from the principal ſcenes, diſplaying ſevere and bitter expoſtulations between Lord Townley and his lady. The ſame objection touches not the double plot of the Careleſs Huſband; the different ſubjects being ſweetly connected, and having only ſo much variety as to reſemble ſhades of colours harmoniouſly mixed. But this is not all. The under-plot ought to be connected with that which is principal, ſo much at leaſt as to employ the ſame perſons: the under-plot ought to occupy the intervals or pauſes of the principal action; and both ought to be concluded together. This is the caſe of the Merry Wives of Windſor.

98 Double plot in a drama ſeldom ſucceſsful.

Violent action ought never to be repreſented on the ſtage. While the dialogue goes on, a thouſand particulars

99 Violent action ought not to be repreſented.

(E) Homer's deſcription of the ſhield of Achilles is properly introduced at a time when the action relents, and the reader can bear an interruption. But the author of Telemachus deſcribes the ſhield of that young hero in the heat of battle; a very improper time for an interruption.

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culars concur to delude us into an impreffion of reality; genuine fentiments, paffionate language, and perfuafive gefture: the fpectator, once engaged, is willing to be deceived, lofes fight of himfelf, and without fcruple enjoys the fpectacle as a reality. From this abfent ftate he is roufed by violent action; he wakes as from a pleafing dream; and, gathering his fenfes about him, finds all to be a fiction. Horace delivers the fame rule; and founds it upon the fame reafon:

> Ne pueros coram populo Medea trucidet;
> Aut humana palam coquat exta nefarius Atreus;
> Aut in avem Progne vertatur, Cadmus in anguem:
> Quodcumque oftendis mihi fic, incredulus odi.

The French critics join with Horace in excluding blood from the ftage; but overlooking the moft fubftantial objection, they urge only that it is barbarous and fhocking to a polite audience. The Greeks had no notion of fuch delicacy, or rather effeminacy; witnefs the murder of Clytemneftra by her fon Oreftes, paffing behind the fcene, as reprefented by Sophocles: her voice is heard calling out for mercy, bitter expoftulations on his part, loud fhrieks upon her being ftabbed, and then a deep filence. An appeal may be made to every perfon of feeling, whether this fcene be not more horrible than if the deed had been committed in fight of the fpectators upon a fudden guft of paffion. If Corneille, in reprefenting the affair between Horatius and his fifter, upon which the murder enfues behind the fcene, had no other view but to remove from the fpectators a fhocking action, he was guilty of a capital miftake: for murder in cold blood, which in fome meafure was the cafe as reprefented, is more fhocking to a polite audience, even where the conclufive ftab is not feen, than the fame act performed in their prefence by violent and unpremeditated paffion, as fuddenly repented of as committed. Addifon's obfervation is juft*, That no part of this incident ought to have been reprefented, but referved for a narrative, with every alleviating circumftance in favour of the hero.

* Spectator, Nº 44.

100 The proper conduct of the dialogue.

A few words upon the dialogue, which ought to be fo conducted as to be a true reprefentation of nature. We talk not here of the fentiments nor of the language (which are treated elfewhere); but of what properly belongs to dialogue-writing; where every fingle fpeech, fhort or long, ought to arife from what is faid by the former fpeaker, and furnifh matter for what comes after till the end of the fcene. In this view, all the fpeeches from firft to laft reprefent fo many links of one regular chain. No author, ancient or modern, poffeffes the art of dialogue equal to Shakefpeare. Dryden, in that particular, may juftly be placed as his oppofite. He frequently introduces three or four perfons fpeaking upon the fame fubject, each throwing out his own notions feparately, without regarding what is faid by the reft: take for an example the firft fcene of Aurenzebe. Sometimes he makes a number club in relating an event, not to a ftranger, fuppofed ignorant of it, but to one another, for the fake merely of fpeaking; of which notable fort of dialogue we have a fpecimen in the firft fcene of the firft part of the Conqueft of Granada. In the fecond part of the fame tragedy, fcene fecond, the King, Abenamar, and Zulema, make their feparate obfervations, like fo many foliloquies, upon the fluctuating temper of the mob; a dialogue fo uncouth puts one in mind of two fhepherds in a paftoral excited by a prize to pronounce verfes alternately, each in praife of his own miftrefs.

This manner of dialogue-writing, befides an unnatural air, has another bad effect; it ftays the courfe of the action, becaufe it is not productive of any confequence. In Congreve's comedies, the action is often fufpended to make way for a play of wit.

No fault is more common among writers than to prolong a fpeech after the impatience of the perfon to whom it is addreffed ought to prompt him or her to break in. Confider only how the impatient actor is to behave in the mean time. To exprefs his impatience in violent action without interrupting would be unnatural; and yet to diffemble his impatience, by appearing cool where he ought to be highly inflamed, would be no lefs fo.

Rhyme being unnatural and difguftful in dialogue, is happily banifhed from our theatre: the only wonder is that it ever found admittance, efpecially among a people accuftomed to the more manly freedom of Shakefpeare's dialogue. By banifhing rhyme, we have gained fo much as never once to dream that there can be any further improvement. And yet, however fuitable blank verfe may be to elevated characters and warm paffions, it muft appear improper and affected in the mouths of the lower fort. Why then fhould it be a rule, That every fcene in tragedy muft be in blank verfe? Shakefpeare, with great judgement, has followed a different rule; which is, to intermix profe with verfe, and only to employ the latter where it is required by the importance or dignity of the fubject. Familiar thoughts and ordinary facts ought to be expreffed in plain language: to hear, for example, a footman deliver a fimple meffage in blank verfe muft appear ridiculous to every one who is not biaffed by cuftom. In fhort, that variety of characters and of fituations, which is the life of a play, requires not only a fuitable variety in the fentiments, but alfo in the diction.

§ 3. *The Three Unities.*

When we confider the chain of caufes and effects in the material world, independent of purpofe, defign, or thought, we find a number of incidents in fucceffion, without beginning, middle, or end: every thing that happens is both a caufe and an effect; being the effect of what goes before, and the caufe of what follows: one incident may affect us more, another lefs; but all of them are links in the univerfal chain: the mind, in viewing thefe incidents, cannot reft or fettle ultimately upon any one; but is carried along in the train without any clofe.

101 In what the unity of action confifts.

But when the intellectual world is taken under view, in conjunction with the material, the fcene is varied. Man acts with deliberation, will, and choice: he aims at fome end; glory, for example, or riches, or conqueft, the procuring happinefs to individuals, or to his country in general: he propofes means, and lays plans to attain the end propofed. Here are a number of facts or incidents leading to the end in view, the whole compofing one chain by the relation of caufe and effect. In running over a feries of fuch facts or incidents, we cannot reft upon any one; becaufe they are prefented to us as means only, leading to fome end; but we reft with fatisfaction upon the end or ultimate event; becaufe there the purpofe or aim of the chief perfon or perfons is accomplifhed. This indicates the beginning, the middle, and

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and the end, of what Aristotle calls *an entire action* *. The story naturally begins with describing those circumstances which move the person who acts the principal part to form a plan, in order to compass some desired event; the prosecution of that plan, and the obstructions, carry the reader into the heat of action; the middle is properly where the action is the most involved; and the end is where the event is brought about, and the plan accomplished.

* *Poet.* c. 6.

We have given the foregoing example of a plan crowned with success, because it affords the clearest conception of a beginning, a middle, and an end, in which consists *unity* of action; and indeed stricter unity cannot be imagined than in that case. But an action may have unity, or a beginning, middle, and end, without so intimate a relation of parts; as where the catastrophe is different from what is intended or desired, which frequently happens in our best tragedies. In the Æneid, the hero, after many obstructions, makes his plan effectual. The Iliad is formed upon a different model: it begins with the quarrel between Achilles and Agamemnon; goes on to describe the several effects produced by that cause; and ends in a reconciliation. Here is unity of action, no doubt, a beginning, a middle, and an end; but inferior to that of the Æneid, which will thus appear. The mind hath a propensity to go forward in the chain of history; it keeps always in view the expected event; and when the incidents or underparts are connected by their relation to the event, the mind runs sweetly and easily along them. This pleasure we have in the Æneid. It is not altogether so pleasant to connect, as in the Iliad, effects by their common cause; for such connection forces the mind to a continual retrospect; looking backward is like walking backward.

Elem. of Criticism.

102 Unity of action a capital beauty.

If unity of action be a capital beauty in fable imitative of human affairs, a plurality of unconnected fables must be a capital deformity. For the sake of variety we indulge an under-plot that is connected with the principal; but two unconnected events are extremely unpleasant, even where the same actors are engaged in both. Ariosto is quite licentious in that particular: he carries on at the same time a plurality of unconnected stories. His only excuse is, that his plan is perfectly well adjusted to his subject; for every thing in the *Orlando Furioso* is wild and extravagant.

Though to state facts in the order of time be natural, yet that order may be varied for the sake of conspicuous beauties. If, for example, a noted story, cold and simple in its first movements, be made the subject of an epic poem, the reader may be hurried into the heat of action; reserving the preliminaries for a conversation piece, if thought necessary; and that method, at the same time, has a peculiar beauty from being dramatic. But a privilege that deviates from nature ought to be sparingly indulged; and yet romance writers make no difficulty of presenting to the reader, without the least preparation, unknown persons engaged in some arduous adventure equally unknown. In Cassandra, two personages, who afterwards are discovered to be the heroes of the fable, start up completely armed upon the banks of the Euphrates, and engage in a single combat.

A play analysed is a chain of connected facts, of which each scene makes a link. Each scene, accordingly, ought to produce some incident relative to the catastrophe or ultimate event, by advancing or retarding it. A scene that produceth no incident, and for that reason may be termed *barren*, ought not to be indulged, because it breaks the unity of action: a barren scene can never be intitled to a place, because the chain is complete without it. In the Old Bachelor, the 3d scene of act 2. and all that follow to the end of that act, are mere conversation-pieces, productive of no consequence. The 10th and 11th scenes, act 3. Double Dealer, and the 10th, 11th, 12th, 13th, and 14th scenes, act 1. Love for Love, are of the same kind. Neither is The Way of World entirely guiltless of such scenes. It will be no justification that they help to display characters: it were better, like Dryden in his *dramatis personæ*, to describe characters beforehand, which would not break the chain of action. But a writer of genius has no occasion for such artifice; he can display the characters of his personages much more to the life in sentiment and action. How successfully is this done by Shakespeare! in whose works there is not to be found a single barren scene.

Upon the whole, it appears, that all the facts in an historical fable ought to have a mutual connection, by their common relation to the grand event or catastrophe. And this relation, in which the *unity* of action consists, is equally essential to epic and dramatic compositions.

103 Whether unity of time and of place be essential.

How far the unities of time and of place are essential, is a question of greater intricacy. These unities were strictly observed in the Greek and Roman theatres; and they are inculcated by the French and English critics as essential to every dramatic composition. In theory these unities are also acknowledged by our best poets, though their practice seldom corresponds: they are often forced to take liberties, which they pretend not to justify, against the practice of the Greeks and Romans, and against the solemn decision of their own countrymen. But in the course of this inquiry it will be made evident, that in this article we are under no necessity to copy the ancients; and that our critics are guilty of a mistake, in admitting no greater latitude of place and time than was admitted in Greece and Rome.

Indeed the unities of place and time are not, by the most rigid critics, required in a narrative poem. In such composition, if it pretend to copy nature, these unities would be absurd; because real events are seldom confined within narrow limits either of place or of time: and yet we can follow history, or an historical fable, through all its changes, with the greatest facility; we never once think of measuring the real time by what is taken in reading; nor of forming any connection between the place of action and that which we occupy.

We are aware, that the drama differs so far from the epic as to admit different rules. It will be observed, "That an historical fable, intended for reading solely, is under no limitation of time or of place more than a genuine history; but that a dramatic composition cannot be accurately represented unless it be limited, as its representation is, to one place and to a few hours; and therefore that no fable can be admitted but what has these properties, because it would be absurd to compose a piece for representation that cannot be justly represented." This argument has at least a plausible appearance; and yet one is apt to suspect some fallacy, considering that no critic, however strict, has ventured to confine the unities of place and of time within so narrow bounds.

A view of the Grecian drama, compared with our own, may

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may perhaps relieve us from this dilemma: if they be differently conſtructed, as ſhall be made evident, it is poſſible that the foregoing reaſoning may not be equally applicable to both.

104 They were eſſential to the Greek drama, but

All authors agree, that tragedy in Greece was derived from the hymns in praiſe of Bacchus, which were ſung in parts by a chorus. Theſpis, to relieve the ſingers, and for the ſake of variety, introduced one actor, whoſe province it was to explain hiſtorically the ſubject of the ſong, and who occaſionally repreſented one or other perſonage. Eſchylus, introducing a ſecond actor, formed the dialogue; by which the performance became dramatic; and the actors were multiplied when the ſubject repreſented made it neceſſary. But ſtill the chorus, which gave a beginning to tragedy, was conſidered as an eſſential part. The firſt ſcene, generally, unfolds the preliminary circumſtances that lead to the grand event; and this ſcene is by Ariſtotle termed the *prologue*. In the ſecond ſcene, where the action properly begins, the chorus is introduced, which, as originally, continues upon the ſtage during the whole performance: the chorus frequently makes one in the dialogue; and when the dialogue happens to be ſuſpended, the chorus, during the interval, is employed in ſinging. Sophocles adheres to this plan religiouſly. Euripides is not altogether ſo correct. In ſome of his pieces it becomes neceſſary to remove the chorus for a little time: but when that unuſual ſtep is riſked, matters are ſo ordered as not to interrupt the repreſentation: the chorus never leave the ſtage of their own accord, but at the command of ſome principal perſonage, who conſtantly waits their return.

Thus the Grecian drama is a continued repreſentation without any interruption; a circumſtance that merits attention. A continued repreſentation without a pauſe affords not opportunity to vary the place of action, nor to prolong the time of the action beyond that of the repreſentation. To a repreſentation ſo confined in place and time, the foregoing reaſoning is ſtrictly applicable: a real or feigned action, that is brought to a concluſion after conſiderable intervals of time and frequent changes of place, cannot accurately be copied in a repreſentation that admits no latitude in either. Hence it is, that the unities of place and of time, were, or ought to have been, ſtrictly obſerved in the Greek tragedies; which is made neceſſary by the very conſtitution of their drama, for it is abſurd to compoſe a tragedy that cannot be juſtly repreſented.

105 not to the French or Engliſh.

Modern critics, who for our drama pretend to eſtabliſh rules founded on the practice of the Greeks, are guilty of an egregious blunder. The unities of place and of time were in Greece, as we ſee, a matter of neceſſity, not of choice; and it is eaſy to ſhow, that if we ſubmit to ſuch fetters, it muſt be from choice, not neceſſity. This will be evident upon taking a view of the conſtitution of our drama, which differs widely from that of Greece; whether more or leſs perfect, is a different point, to be handled afterward. By dropping the chorus, opportunity is afforded to divide the repreſentation by intervals of time, during which the ſtage is evacuated and the ſpectacle ſuſpended. This qualifies our drama for ſubjects ſpread through a wide ſpace both of time and of place: the time ſuppoſed to paſs during the ſuſpenſion of the repreſentation is not meaſured by the time of the ſuſpenſion; and any place may be ſuppoſed, as it is not in ſight: by which means, many ſubjects can be juſtly repreſented in our theatres, that were excluded from thoſe of ancient Greece. This doctrine may be illuſtrated, by comparing a modern play to a ſet of hiſtorical pictures; let us ſuppoſe them five in number, and the reſemblance will be complete: each of the pictures reſembles an act in one of our plays: there muſt neceſſarily be the ſtricteſt unity of place and of time in each picture; and the ſame neceſſity requires theſe two unities during each act of a play, becauſe during an act there is no interruption in the ſpectacle. Now, when we view in ſucceſſion a number of ſuch hiſtorical pictures, let it be, for example, the hiſtory of Alexander by Le Brun, we have no difficulty to conceive, that months or years have paſſed between the events exhibited in two different pictures, though the interruption is imperceptible in paſſing our eye from the one to the other; and we have as little difficulty to conceive a change of place, however great: in which view, there is truly no difference between five acts of a modern play and five ſuch pictures. Where the repreſentation is ſuſpended, we can with the greateſt facility ſuppoſe any length of time or any change of place: the ſpectator, it is true, may be conſcious, that the real time and place are not the ſame with what are employed in the repreſentation; but this is a work of reflection; and by the ſame reflection he may alſo be conſcious, that Garrick is not King Lear, that the playhouſe is not Dover cliffs, nor the noiſe he hears thunder and lightning. In a word, after an interruption of the repreſentation, it is not more difficult for a ſpectator to imagine a new place, or a different time, than, at the commencement of the play, to imagine himſelf at Rome, or in a period of time two thouſand years back. And indeed, it is abundantly ridiculous, that a critic, who is willing to hold candle-light for ſunſhine, and ſome painted canvaſſes for a palace or a priſon, ſhould affect ſo much difficulty in imagining a latitude of place or of time in the fable, beyond what is neceſſary in the repreſentation.

106 Great latitude in time, however not to be indulged,

There are, it muſt be acknowledged, ſome effects of great latitude in time that ought never to be indulged in a compoſition for the theatre: nothing can be more abſurd, than at the cloſe to exhibit a full-grown perſon who appears a child at the beginning: the mind rejects, as contrary to all probability, ſuch latitude of time as is requiſite for a change ſo remarkable. The greateſt change from place to place hath not altogether the ſame bad effect: in the bulk of human affairs place is not material; and the mind, when occupied with an intereſting event, is little regardful of minute circumſtances: theſe may be varied at will, becauſe they ſcarcely make any impreſſion.

107 nor in place.

At the ſame time, it is not here meant to juſtify liberty without any reſerve. An unbounded licence with relation to place and time, is faulty, for a reaſon that ſeems to have been overlooked, which is, that it ſeldom fails to break the unity of action: in the ordinary courſe of human affairs, ſingle events, ſuch as are fit to be repreſented on the ſtage, are confined to a narrow ſpot, and generally employ no great extent of time; and accordingly we ſeldom find ſtrict unity of action in a dramatic compoſition, where any remarkable latitude is indulged in theſe particulars. It may even be admitted, that a compoſition which employs but one place, and requires not a greater length of time than is neceſſary for the repreſentation, is ſo

Elem. of Criticiſm, chap. 23.

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so much the more perfect; because the confining an event within so narrow bounds, contributes to the unity of action, and also prevents that labour, however slight, which the mind must undergo in imagining frequent changes of place, and many intervals of time. But still we must insist, that such limitation of place and time as was necessary in the Grecian drama, is no rule to us; and therefore, that though such limitation adds one beauty more to the composition, it is at best but a refinement, which may justly give place to a thousand beauties more substantial. And we may add, that it is extremely difficult, if not impracticable, to contract within the Grecian limits any fable so fruitful of incidents in number and variety as to give full scope to the fluctuation of passion.

It may now appear, that critics who put the unities of place and of time upon the same footing with the unity of action, making them all equally essential, have not attended to the nature and constitution of the modern drama. If they admit an interrupted representation, with which no writer finds fault, it is absurd to reject its greatest advantage, that of representing many interesting subjects excluded from the Grecian stage. If there needs must be a reformation, why not restore the ancient chorus and the ancient continuity of action? There is certainly no medium; for to admit an interruption without relaxing from the strict unities of place and of time, is in effect to load us with all the inconveniences of the ancient drama, and at the same time to withhold from us its advantages.

108 Whether our drama be preferable to that of Greece.

And therefore the only proper question is, Whether our model be or be not a real improvement? This indeed may fairly be called in question; and in order to a comparative trial, some particulars must be premised. When a play begins, we have no difficulty to adjust our imagination to the scene of action, however distant it be in time or in place; because we know that the play is a representation only. The case is very different after we are engaged: it is the perfection of representation to hide itself, to impose on the spectator, and to produce in him an impression of reality, as if he were spectator of a real event; but any interruption annihilates that impression, by rousing him out of his waking dream, and unhappily restoring him to his senses. So difficult it is to support the impression of reality, that much slighter interruptions than the interval between two acts are sufficient to dissolve the charm: in the 5th act of the *Mourning Bride*, the three first scenes are in a room of state, the fourth in a prison; and the change is operated by shifting the scene, which is done in a trice: but however quick the transition may be, it is impracticable to impose upon the spectators so as to make them conceive that they are actually carried from the palace to the prison; they immediately reflect, that the palace and prison are imaginary, and that the whole is a fiction.

From these premises, one will naturally be led, at first view, to pronounce the frequent interruptions in the modern drama to be an imperfection. It will occur, "That every interruption must have the effect to banish the dream of reality, and with it to banish our concern, which cannot subsist while we are conscious that all is a fiction; and therefore, that in the modern drama, sufficient time is not afforded for fluctuation and swelling of passion, like what is afforded in that of Greece, where there is no interruption." This reasoning, it must be owned, has a specious appearance: but we must not become faint-hearted upon the first repulse; let us rally our troops for a second engagement.

On the Greek stage, whatever may have been the case on the Roman, the representation was never interrupted, and the division by acts was totally unknown. The word *act* never once occurs in Aristotle's Poetics, in which he defines exactly every part of the drama, and divides it into the beginning, the middle, and the end. At certain intervals indeed the actors retired; but the stage was not then left empty, nor the curtain let fall; for the chorus continued and sung. Neither do these songs of the chorus divide the Greek tragedies into five portions similar to our acts; though some of the commentators have endeavoured to force them into this office. But it is plain, that the intervals at which the chorus sung are extremely unequal and irregular, suited to the occasion and the subject; and would divide the play sometimes into three, sometimes into seven or eight acts.

As practice has now established a different plan on the modern stage, has divided every play into five acts, and made a total pause in the representation at the end of each act, the question to be considered is, Whether the plan of the ancient or of the modern drama is best qualified for making a deep impression on the mind? That the preference is due to the plan of the modern drama, will be evident from the following considerations. If it be indeed true, as the advocates for the three unities allege, that the audience is deluded into the belief of the reality of a well-acted tragedy, it is certain that this delusion cannot be long supported; for when the spirits are exhausted by close attention, and by the agitation of passion, an uneasiness ensues, which never fails to banish the waking dream. Now supposing the time that a man can employ with strict attention without wandering to be no greater than is requisite for a single act (a supposition that cannot be far from truth), it follows, that a continued representation of longer endurance than an act, instead of giving scope to fluctuation and swelling of passion, would overstrain the attention, and produce a total absence of mind. In this respect, the four pauses have a fine effect: for by affording to the audience a seasonable respite when the impression of reality is gone, and while nothing material is in agitation, they relieve the mind from its fatigue; and consequently prevent a wandering of thought at the very time possibly of the most interesting scenes.

In one article, indeed, the Grecian model has greatly the advantage: its chorus, during an interval, not only preserves alive the impressions made upon the audience, but also prepares their hearts finely for new impressions. In our theatres, on the contrary, the audience, at the end of every act, being left to trifle time away, lose every warm impression; and they begin the next act cool and unconcerned, as at the commencement of the representation. This is a gross malady in our theatrical representations; but a malady that luckily is not incurable: to revive the Grecian chorus, would be to revive the Grecian slavery of place and time; but we can figure a detached chorus coinciding with a pause in the representation, as the ancient chorus did with a pause in the principal action. What objection, for example, can there lie against music between the acts, vocal and instrumental,

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instrumental, adapted to the ſubject? Such detached chorus, without putting us under any limitation of time or place, would recruit the ſpirits, and would preſerve entire the tone, if not the tide, of paſſion: the muſic, after an act, ſhould commence in the tone of the preceding paſſion, and be gradually varied till it accord with the tone of the paſſion that is to ſucceed in the next act. The muſic and the repreſentation would both of them be gainers by their conjunction; which will thus appear. Muſic that accords with the preſent tone of mind, is, on that account, doubly agreeable; and accordingly, though muſic ſingly hath not power to raiſe a paſſion, it tends greatly to ſupport a paſſion already raiſed. Further, muſic prepares us for the paſſion that follows, by making cheerful, tender, melancholy, or animated impreſſions, as the ſubject requires. Take for an example the firſt ſcene of the *Mourning Bride*, where ſoft muſic, in a melancholy ſtrain, prepares us for Almeria's deep diſtreſs. In this manner, muſic and repreſentation ſupport each other delightfully: the impreſſion made upon the audience by the repreſentation, is a fine preparation for the muſic that ſucceeds; and the impreſſion made by the muſic is a fine preparation for the repreſentation that ſucceeds. It appears evident, that by ſome ſuch contrivance, the modern drama may be improved, ſo as to enjoy the advantage of the ancient chorus without its ſlaviſh limitation of place and time. But to return to the compariſon between the ancient and the modern drama.

109 An improvement of the modern drama ſuggeſted. *Elem. of Criticiſm*, chap. 23.

110 The modern drama preferable to the ancient.

The numberleſs improprieties forced upon the Greek dramatic poets by the conſtitution of their drama, may be ſufficient, one ſhould think, to make us prefer the modern drama, even abſtracting from the improvement propoſed. To prepare the reader for this article, it muſt be premiſed, that as in the ancient drama the place of action never varies, a place neceſſarily muſt be choſen to which every perſon may have acceſs without any improbability. This confines the ſcene to ſome open place, generally the court or area before a palace; which excludes from the Grecian theatre tranſactions within doors, though theſe commonly are the moſt important. Such cruel reſtraint is of itſelf ſufficient to cramp the moſt pregnant invention; and accordingly the Greek writers, in order to preſerve unity of place, are reduced to woful improprieties. In the *Hippolytus* of Euripides (act i. ſc. 6.), Phædra, diſtreſſed in mind and body, is carried without any pretext from her palace to the place of action; is there laid upon a couch, unable to ſupport herſelf upon her limbs; and made to utter many things improper to be heard by a number of women who form the chorus: and what is ſtill more improper, her female attendant uſes the ſtrongeſt intreaties to make her reveal the ſecret cauſe of her anguiſh; which at laſt Phædra, contrary to decency and probability, is prevailed upon to do in preſence of that very chorus (act ii. ſc. 2.). Alceſtes, in Euripides, at the point of death, is brought from the palace to the place of action, groaning and lamenting her untimely fate (act ii. ſc. 1.). In the *Trachiniæ* of Sophocles (act ii.), a ſecret is imparted to Dejanira, the wife of Hercules, in preſence of the chorus. In the tragedy of *Iphigenia*, the meſſenger employed to inform Clytemneſtra that Iphigenia was ſacrificed, ſtops ſhort at the place of action, and with a loud voice calls the queen from her palace to hear the news. Again, in the *Iphigenia in Tauris* (act iv.), the neceſſary preſence of the chorus forces Euripides into a groſs abſurdity, which is to form a ſecret in their hearing; and, to diſguiſe the abſurdity, much court is paid to the chorus, not one woman but a number, to engage them to ſecrecy. In the *Medea* of Euripides, that princeſs makes no difficulty, in preſence of the chorus, to plot the death of her huſband, of his miſtreſs, and of her father the king of Corinth, all by poiſon: it was neceſſary to bring Medea upon the ſtage; and there is but one place of action, which is always occupied by the chorus. This ſcene cloſes the ſecond act; and in the end of the third, ſhe frankly makes the chorus her confidants in plotting the murder of her own children. Terence, by identity of place, is often forced to make a converſation within doors be heard on the open ſtreet: the cries of a woman in labour are there heard diſtinctly.

111 Inconveniences of the plan of the ancient drama.

The Greek poets are not leſs hampered by unity of time than by that of place. In the *Hippolytus* of Euripides, that prince is baniſhed at the end of the 4th act; and in the firſt ſcene of the following act, a meſſenger relates to Theſeus the whole particulars of the death of Hippolytus by the ſea-monſter: that remarkable event muſt have occupied many hours; and yet in the repreſentation it is confined to the time employed by the chorus upon the ſong at the end of the 4th act. The inconſiſtency is ſtill greater in the *Iphigenia in Tauris* (act v. ſc. 4.): the ſong could not exhauſt half an hour; and yet the incidents ſuppoſed to have happened during that time could not naturally have been tranſacted in leſs than half a day.

The Greek artiſts are forced, not leſs frequently, to tranſgreſs another rule, derived alſo from a continued repreſentation. The rule is, that as a vacuity, however momentary, interrupts the repreſentation, it is neceſſary that the place of action be conſtantly occupied. Sophocles, with regard to that rule as well as to others, is generally correct: but Euripides cannot bear ſuch reſtraint; he often evacuates the ſtage, and leaves it empty for others. Iphigenia in Tauris, after pronouncing a ſoliloquy in the firſt ſcene, leaves the place of action, and is ſucceeded by Oreſtes and Pylades: they, after ſome converſation, walk off; and Iphigenia re-enters, accompanied with the chorus. In the Alceſtes, which is of the ſame author, the place of action is void at the end of the third act. It is true, that to cover the irregularity, and to preſerve the repreſentation in motion, Euripides is careful to fill the ſtage without loſs of time: but this ſtill is an interruption, and a link of the chain broken: for during the change of the actors, there muſt be a ſpace of time, during which the ſtage is occupied by neither ſet. It makes indeed a more remarkable interruption, to change the place of action as well as the actors; but that was not practicable upon the Grecian ſtage.

It is hard to ſay upon what model Terence has formed his plays. Having no chorus, there is a pauſe in the repreſentation at the end of every act: but advantage is not taken of the ceſſation, even to vary the place of action; for the ſtreet is always choſen, where every thing paſſing may be ſeen by every perſon; and by that choice, the moſt ſprightly and intereſting parts of the action, which commonly paſs within doors, are excluded;

The three Unities.

ed; witneſs the laſt act of the *Eunuch*. He hath ſubmitted to the like ſlavery with reſpect to time. In a word, a play with a regular chorus, is not more confined in place and time than his plays are. Thus a zealous ſectary follows implicitly ancient forms and ceremonies, without once conſidering whether their introductive cauſe be ſtill ſubſiſting. Plautus, of a bolder genius than Terence, makes good uſe of the liberty afforded by an interrupted repreſentation: he varies the place of action upon all occaſions, when the variation ſuits his purpoſe.

Elem. of Criticiſm, chap. 23.

112 No change of time or place to be admitted but between the acts.

The intelligent reader will by this time underſtand, that we plead for no change of place in our plays but after an interval, nor for any latitude in point of time but what falls in with an interval. The unities of place and time ought to be ſtrictly obſerved during each act; for during the repreſentation there is no opportunity for the ſmalleſt deviation from either. Hence it is an eſſential requiſite, that during an act the ſtage be always occupied; for even a momentary vacuity makes an interval or interruption. Another rule is no leſs eſſential: it would be a groſs breach of the unity of action to exhibit upon the ſtage two ſeparate actions at the ſame time; and therefore, to preſerve that unity, it is neceſſary that each perſonage introduced during an act be linked to thoſe in poſſeſſion of the ſtage, ſo as to join all in one action. Theſe things follow from the very conception of an act, which admits not the ſlighteſt interruption: the moment the repreſentation is intermitted, there is an end of that act; and we have no other notion of a new act, but where, after a pauſe or interval, the repreſentation is again put in motion. French writers, generally ſpeaking, are correct in this particular. The Engliſh, on the contrary, are ſo irregular as ſcarce to deſerve a criticiſm; actors not only ſucceed each other in the ſame place without connection, but, what is ſtill leſs excuſable, they frequently ſucceed each other in different places. This change of place in the ſame act ought never to be indulged; for, beſide breaking the unity of the act, it has a diſagreeable effect: after an interval, the imagination adapts itſelf to any place that is neceſſary, as readily as at the commencement of the play; but during the repreſentation we reject change of place. From the foregoing cenſure muſt be excepted the *Mourning Bride* of Congreve, where regularity concurs with the beauty of ſentiment and of language, to make it one of the moſt complete pieces England has to boaſt of. It is acknowledged, however, that in point of regularity this elegant performance is not altogether unexceptionable. In the four firſt acts, the unities of place and time are ſtrictly obſerved: but in the laſt act, there is a capital error with reſpect to unity of place; for in the three firſt ſcenes of that act, the place of action is a room of ſtate, which is changed to a priſon in the fourth ſcene: the chain alſo of the actors is broken; as the perſons introduced in the priſon are different from thoſe who made their appearance in the room of ſtate. This remarkable interruption of the repreſentation makes in effect two acts inſtead of one: and therefore, if it be a rule that a play ought not to conſiſt of more acts than five, this performance is ſo far defective in point of regularity. It may be added, that, even admitting ſix acts, the irregularity would not be altogether removed, without a longer pauſe in the repreſentation than is allowed in the acting; for more than a momentary interruption is requiſite for enabling the imagination readily to fall in with a new place, or with a wide ſpace of time. In *The Way of the World*, of the ſame author, unity of place is preſerved during every act, and a ſtricter unity of time during the whole play than is neceſſary.

Of the Opera.

§ 4. *Of the Opera.*

113 The opera, a drama repreſented by muſic.

An opera is a drama repreſented by muſic. This entertainment was invented at Venice. An exhibition of this ſort requires a moſt brilliant magnificence, and an expence truly royal. The drama muſt neceſſarily be compoſed in verſe; for as operas are ſung and accompanied with ſymphonies, they muſt be in verſe to be properly applicable to muſic. To render this entertainment ſtill more brilliant, it is ornamented with dances and ballets, with ſuperb decorations, and ſurpriſing machinery. The dreſſes of the actors, of thoſe who aſſiſt in the chorus, and of the dancers, being all in the moſt ſplendid and elegant taſte, contribute to render the exhibition highly ſumptuous. But notwithſtanding this union of arts and pleaſures at an immenſe expence, and notwithſtanding a moſt dazzling pageantry, an opera appears, in the eyes of many people of taſte, but as a magnificent abſurdity, ſeeing that nature is never there from the beginning to the end. It is not our buſineſs here, however, to determine between the different taſtes of mankind.

The method of expreſſing our thoughts by ſinging and muſic is ſo little natural, and has ſomething in it ſo forced and affected, that it is not eaſy to conceive how it could come into the minds of men of genius to repreſent any human action, and, what is more, a ſerious or tragic action, any otherwiſe than by ſpeech. We have, it is true, operas in Engliſh by Addiſon, &c. in Italian by Metaſtaſio, in French by M. Quinault, Fontenelle, &c. the ſubjects of which are ſo grave and tragic, that one might call them muſical tragedies, and real *chefs d'œuvres* in their kind. But though we are highly ſatisfied and greatly affected on reading them, and are much pleaſed with ſeeing them repreſented, yet the ſpectator is, perhaps, more charmed with the magnificence of the ſight and the beauty of the muſic, than moved with the action and the tragical part of the performance. We are not, however, of that order of critics who ſtrive to prove, that mankind act wrong in finding pleaſure in an object with which they are really pleaſed; who blame a lover for thinking his miſtreſs charming, when her features are by no means regular; and who are perpetually applying the rules of logic to the works of genius: we make theſe obſervations merely in order to examine if it be not poſſible to augment the pleaſures of a polite people, by making the opera ſomething more natural, more probable, and more conſonant to reaſon.

Bielfield's Elem. of Erudition.

114 ſhould take its ſubject not from hiſtory but from fable and enchantment.

We think, therefore, that the poet ſhould never, or at leaſt very rarely, chooſe a ſubject from hiſtory, but from fable or mythology, or from the regions of enchantment. Every rational mind is conſtantly ſhocked to hear a mutilated hero trill out, from the ſlender pipe of a chaffinch, *To arms! To arms!* and in the ſame tone animate his ſoldiers, and lead them to the aſſault; or harangue an aſſembly of grave ſenators, and ſometimes a whole body of people. Nothing can be

more

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more burlefque than fuch exhibitions; and a man muft be poffeffed of a very uncommon fenfibility to be affected by them. But as we know not what was the language of the gods, and their manner of expreffing themfelves, we are at liberty in that cafe to form what illufions we pleafe, and to fuppofe that they fung to diftinguifh themfelves from mortals. Befides, all the magic of decorations and machinery become natural, and even neceffary, in thefe kinds of fubjects; and therefore readily afford opportunity for all the pomp of thefe performances. The chorus, the dances, the ballettes, the fymphonies and dreffes, may likewife be all made to correfpond with fuch fubjects, nothing is here affected, abfurd, or unnatural. Whoever is poffeffed of genius, and is well acquainted with mythology, will there find an inexhauftible fource of fubjects highly diverfified, and quite proper for the drama of an opera.

We fhall not fpeak here of that fort of mufic which appears to us the moft proper for fuch a drama, and of the feveral alterations of which we think it fufceptible, in order to make it more complete, and to adapt it to a more pathetic, more noble, and more natural expreffion, as well in the recitatives as in the airs and chorus. (See MUSIC). We have only here to confider the bufinefs of the poet. He fhould never lofe fight of nature, even in the midft of the greateft fiction. A god, a demi-god, a renowned hero, fuch for example as Renaud in *Armida*, a fairy, a genii, a nymph, or fury, &c. fhould conftantly be reprefented according to the characters we give them, and never be made to talk the language of a fop or a *petite maitreffe*. The recitative, which is the ground-work of the dialogue, requires verfes that are free and not regular, fuch as with a fimple cadence approach the neareft to common language. The airs fhould not be forced into the piece, nor improperly placed for the fake of terminating a fcene, or to difplay the voice of a performer: they fhould exprefs fome fentiment, or fome precept, fhort and ftriking, or tender and affecting; or fome fimile lively and natural; and they fhould arife of themfelves from a monologue, or from a fcene between two perfons: prolixity fhould here be particularly avoided, efpecially when fuch an air makes part of a dialogue; for nothing is more infipid or difguftful than the countenances of the other actors who appear at the fame time, whofe filence is quite unmeaning, and who know not what to do with their hands and feet while the finger is ftraining his throat. The verfe of all the airs fhould be of the lyric kind, and fhould contain fome poetic image, or paint fome noble paffion, which may furnifh the compofer with an opportunity of difplaying his talents, and of giving a lively and affecting expreffion to the mufic.' A phrafe that is inanimated can never have a good effect in the performance, but muft become infipid and horribly tedious in the air. The trite fimilies of the Italians, of a ftream that flows, or a bird that flies, &c. are no longer fufferable. The fame thing may be faid with regard to the chorus, which fhould be equally natural and well adapted: it is here fometimes a whole people, fometimes the inhabitants of a peculiar country, and fometimes warriors, nymphs, or priefts, &c. who raife their voice to demand juftice, to implore favour, or render a general homage. The action itfelf will furnifh the poet of genius with ideas, words, and the manner of difpofing them.

115 and fhould reprefent its characters as confiftent.

Laftly, the opera being a performance calculated lefs to fatisfy the underftanding than to charm the ear and affect the heart, and efpecially to ftrike the fight, the poet fhould have a particular attention to that object, fhould be fkilled in the arts of a theatre, fhould know how to introduce combats, ballets, feafts, games, pompous entries, folemn proceffions, and fuch marvellous incidents as occur in the heavens, upon earth, in the fea, and even in the infernal regions: but all thefe matters demand a ftrong character, and the utmoft precifion in the execution: for otherwife, the comic being a near neighbour to the fublime, they will eafily become ridiculous. The unity of action muft certainly be obferved in fuch a poem, and all the incidental epifodes muft concur to the principal defign; otherwife it would be a monftrous chaos. It is impoffible, however, fcrupuloufly to obferve the unity of time and place: though the liberty, which reafon allows the poet in this refpect, is not without bounds; and the lefs ufe he makes of it, the more perfect his poem will be. It is not perhaps impoffible fo to arrange the objects, that, in changing the decorations, the painter may conftantly make appear fome part of the principal decoration which characterifes the fituation of the fcene, as the corner of a palace, at the end of a garden, or fome avenue that leads to it, &c. But all this is liable to difficulties, and even to exceptions; and the art of the painter muft concur in fuch cafe with that of the poet. For the reft, all the operas of Europe are at leaft one third too long; efpecially the Italian. The unity of action requires brevity, and fatiety is infeparable from a diverfion that lafts full four hours, and fometimes longer.

116 Unity of action neceffary to the opera.

They have indeed endeavoured to obviate this inconvenience by dividing an opera into three, and even into five acts; but experience proves, that this divifion, though judicious, is ftill not fufficient to relieve the wearied attention.

SECT. II. *Of Lyric Poetry.*

117 Origin of the ode.

THE ode is very ancient, and was probably the firft fpecies of poetry. It had its fource, we may fuppofe, from the heart, and was employed to exprefs, with becoming fervour and dignity, the grateful fenfe man entertained of the bleffings which daily flowed from God the fountain of all goodnefs: hence their harveft hymns, and other devotional compofitions of that kind.

But in procefs of time it was employed, not only to praife the Almighty for bounties received, but to folicit his aid in time of trouble; as is plain from the odes written by King David and others, and collected by the Jewifh Sanhedrim into the book of Pfalms, to be fung at their fafts, feftivals, and on other folemn occafions. Nor was this practice confined to the Ifraelites only: other nations had their fongs of praife and petitions of this fort, which they preferred to their deities in time of public profperity and public diftrefs, as well as to thofe heroes who diftinguifhed themfelves in arms. Even the American Indians, whofe notions of religion are extremely confined, have their war-fongs, which they fing to this day.

It

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It is reaſonable to ſuppoſe that the awful purpoſe to which the ode was applied, gave riſe among the ancients to the cuſtom of invoking the muſes; and that the poets in order to raiſe their ſentiments and language, ſo as to be acceptable to their deities, thought it expedient to ſolicit ſome divine aſſiſtance. Hence poets are ſaid to have been inſpired, and hence an unbounded liberty has been given to the ode; for the lyric poet, fired, as it were, with his ſubject, and borne away on the wings of gratitude, diſdains grammatical niceties and common modes of ſpeech, and often ſoars above rule, though not above reaſon. This freedom, however, conſiſts chiefly in ſudden tranſitions, bold digreſſions, and lofty excurſions. For the ancient poets, and even Pindar, the moſt daring and lofty of them all, has in his ſublimeſt flights, and amidſt all his rapture, preſerved harmony, and often uniformity in his verſification: but ſo great is the variety of his meaſures, that the traces of ſameneſs are in a manner loſt; and this is one of the excellencies for which that poet is admired, and which, though ſeemingly devoid of art, requires ſo much that he has ſeldom been imitated with ſucceſs.

118 Its freedom.

The ancients in their odes indulged ſuch a liberty of fancy, that ſome of their beſt poets not only make bold excurſions and digreſſions, but, having in their flights ſtarted ſome new and noble thought, they frequently purſue it, and never more return to their ſubject. But this looſe kind of ode, which ſeems to reject all method, and in which the poet, having juſt touched upon his ſubject, immediately diverts to another, we ſhould think blameable, were it lawful to call in queſtion the authority of thoſe great men who were our preceptors in this art. We may venture to affirm, however, that theſe compoſitions ſtand in no degree of compariſon with other odes of theirs; in which, after wandering from the ſubject in purſuit of new ideas ariſing from ſome of its adjuncts, and ranging wantonly, as it were, through a variety of matter, the poet is from ſome other circumſtance led naturally to his ſubject again; and, like a bee, having collected the eſſence of many different flowers, returns home, and unites them all in one uniform pleaſing ſweet.

119 The ſubjects of the ode.

The ode among the ancients ſignified no more than a ſong: but with the moderns, the ode and the ſong are conſidered as different compoſitions; the ode being uſually employed in grave and lofty ſubjects, and ſeldom ſung but on ſolemn occaſions.

The ſubjects moſt proper for the ode and ſong, Horace has pointed out in a few elegant lines.

Gods, heroes, conquerors, *Olympic* crowns,
Love's pleaſing cares, and the free joys of wine,
Are proper ſubjects for the lyric ſong.

To which we may add, that happineſs, the pleaſures of a rural life, and ſuch parts of morality as afford leſſons for the promotion of our felicity, and reflections on the conduct of life, are equally ſuitable to the ode. This both *Pindar* and *Horace* were ſo ſenſible of, that many of their odes are ſeaſoned with theſe moral ſentences and reflections.

But who can number ev'ry ſandy grain
Waſh'd by *Sicilia's* hoarſe-reſounding main?
Or who can *Theron's* gen'rous works expreſs,
And tell how many hearts his bounteous virtues bleſs?
Ode to THERON.

And in another Olympic ode, inſcribed by the ſame poet to Diagoras of Rhodes (and in ſuch eſteem, that it was depoſited in the temple of Minerva, written in letters of gold), Pindar, after exalting them to the ſkies, concludes with this leſſon in life:

Yet as the gales of fortune various blow,
To-day tempeſtuous, and to-morrow fair,
Due bounds, ye Rhodians, let your tranſports know;
Perhaps to-morrow comes a ſtorm of care.
Weſt's PINDAR.

The man reſolv'd and ſteady to his truſt,
Inflexible to ill, and obſtinately juſt,
May the rude rabble's inſolence deſpiſe,
Their ſenſeleſs clamours and tumultuous cries;
The tyrant's fierceneſs he beguiles,
And the ſtern brow and the harſh voice defies.
And with ſuperior greatneſs ſmiles.
Not the rough whirlwind, that deforms
Adria's black gulf, and vexes it with ſtorms,
The ſtubborn virtue of his ſoul can move;
Nor the red arm of angry Jove,
That flings the thunder from the ſky,
And gives it rage to roar, and ſtrength to fly.
Should the whole frame of nature round him break,
In ruin and confuſion hurl'd,
He unconcern'd would hear the mighty crack,
And ſtand ſecure amidſt a falling world.
HORACE.

M. Deſpreaux has given us a very beautiful and juſt deſcription of the ode in the following lines.

L'Ode avec plus d'éclat, & non moins d'énergie
Elevant juſqu'au ciel ſon vol ambitieux,
Entretient dans vers commerce avec les Dieux.
Aux Athletes dans Piſe elle ouvre la barriere,
Chante un vainqueur poudreux au bout de la carriere;
Mene Achille ſanglant au bords du Simoïs
Ou fait flechir l'Eſcaut ſous le joug de Louis.
Tantôt comme une abeille ardente à ſon ouvrage
Elle s'en va de fleurs dèpouiller le rivage:
Elle peint les feſtins, les danſes & les ris,
Vante un baiſer cueilli ſur les levres d'Iris,
Qui mollement réſiſte & par un doux caprice
Quelquefois le refuſe, afin qu'on le raviſſe.
Son ſtyle impetueux ſouvent marche au haſard.
Chez elle un beau deſordre eſt un effet de l'art,
Loin ces rimeurs craintifs, dont l'eſprit phlegmatique
Garde dans ſes fureurs un ordre didactique:
Qui chantant d'un heros les progrès éclatans,
Maigres hiſtoriens, ſuivront l'ordre des temps.
Apollon de ſon feu leur fut toujours avare, &c.

The lofty ode demands the ſtrongeſt fire,
For there the muſe all Phœbus muſt inſpire:
Mounting to heav'n in her ambitious flight,
Amongſt the gods and heroes takes delight;
Of Piſa's wreſtlers tells the ſinewy force,
And ſings the duſty conqueror's glorious courſe;

To

Of Lyric Poetry.

To Simois' banks now fierce Achilles ſends,
Beneath the Gallic yoke now Eſcaut bends:
Sometimes ſhe flies, like an induſtrious bee,
And robs the flow'rs by nature's chemiſtry;
Deſcribes the ſhepherds dances, feaſts, and bliſs,
And boaſts from Phillis to ſurpriſe a kiſs,
When gently ſhe reſiſts with feign'd remorſe,
That what ſhe grants may ſeem to be by force.
Her generous ſtyle will oft at random ſtart,
And by a brave diſorder ſhow her art;
Unlike thoſe fearful poets whoſe cold rhyme
In all their raptures keeps exacteſt time,
Who ſing th' illuſtrious hero's mighty praiſe,
Dry journaliſts, by terms of weeks and days;
To theſe, Apollo, thrifty of his fire,
Denies a place in the Pierian choir, &c.

SOAMES.

POETRY *continued in next Volume.*

END OF THE SIXTEENTH VOLUME.

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