POPULAR ASTRONOMY.

A DESCRIPTION

OF THE

PRINCIPAL PHENOMENA

OF

ASTRONOMY:

INCLUDING

THE SUN; THE SOLAR SYSTEM; PLANETS; THE EARTH AND ITS ATMOSPHERE; THE SEASONS; THE MOON AND ITS PHASES; DAY AND NIGHT; ECLIPSES; TIDES; STARS; NEBULÆ &c.

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POPULAR ASTRONOMY.

In giving a brief sketch of the principal phenomena of Astronomy, it will be desirable to commence with a description of the Solar System.

The Solar System comprises the sun, eight principal planets, and thirty-five minor planets; all of which revolve round the sun as their centre, and are termed primary planets; in addition to these, it also comprises a number of secondary planets or moons, which revolve round some of the primary planets; and an unknown number of bodies called comets.

THE SUN.

The Sun forms the centre of the planetary system, and is a round opaque body, surrounded by a luminous atmosphere, adapted to supply heat and light to all the planets. The sun is distant from the earth about ninety-five million miles; his diameter is 882,000 miles; and his volume or bulk 1,380,000 times greater than that of the earth. The sun rotates upon his axis in twenty-five days eight hours.

Upon looking at the sun through a telescope having coloured glasses, a number of dark spots are usually seen upon its surface. If these spotsbe repeatedly watched, they will be found not to be stationary on the sun's disk for any long period of time, nor to remain of the same shape, but to vary their position, to contract or enlarge, and at times suddenly to disappear; while others break out in places where none beforeexisted. The size of some of the spots is immense; in the year 1758, one was observed which measured 45,000 miles across: indeed, the least possible spot which can be seen by our best glasses, cannot be less than 465 miles in diameter. The result of the investigations into this subject is, that the solar spots are believed to be spaces or openings through the luminous matter, exposing to view portions of the solid body of the sun. By an attentive observer it will be remarked, that such of the spots as remain stationary for a considerable time, have a gradual motion, apparently across the sun's disk. This motion of the spots can only arise from the rotation of the sun on his axis; and they serve to mark the time of this rotation. These spots also prove that the sun is a spherical body; for a spot makes its appearance on the western edge of the sun as a fine line, which gradually increases n breadth till it approaches the centre. As it passes on to the eastern edge, its diameter gradually lessens into a fine line, before it entirely vanishes from view.

With regard to the question, whether or not the sun is inhabited, astronomers are undecided. Sir William Hershel, from what he had observed in that luminary, states as follows: "The sun appears to be nothing else than a very eminent, large, and lucid planet; evidently the first, or rather, the only primary one of our system, all the rest being secondary to it. Its similarity to the other globes of the solar system, with regard to its solidity, its atmosphere, and its diversified surface, leads us to suppose that it is most probably also inhabited, like the rest of the planets, by beings whose organs are adapted to the peculiar circumstances of that vast globe."

Owing to the great difference in the distances of the various planets from the sun and which will be described presently, it will be evident that he must present to their various inhabitants different degrees of magnitude. Thus, to Mercury, he appears as a globe far larger than he does to us, while to the inhabitants of Neptune, he must appear little larger than a star point. The former planet being only 37 millions of miles distant from him, while the latter view him from the enormous distance of 2,800 millions.

THE PLANETS

Round the sun revolve tne planets, in orbits not circular, but more or less elliptical or oval. The planets are opaque, solid, globular bodies, which receive their light and heat from the sun; they all rotate upon their axis, and consequently, all enjoy the alternations of day and night. Their axis is also more or less inclined to the plane of their orbit; they therefore experience, to a greater or less degree, the caused by the ochry tinge of the soil beneath. Clear indications of continents and seas are disclosed by the telescope, the seas presenting a greenish hue. A brilliant white district from time to time is observed in the neighbourhood of his north pole, which decreases in size when it is turned towards the sun. It is highly probable that this is the accumulations of snow and ice formed during his long polar winters of twelve months duration, which melt before the sun as the summer season returns. The axis of Mars is inclined to the ecliptic about 30 degrees 18 minutes; hence his seasons must be very similar to those of the earth, but of different length; he has also nearly the same intervals of day and night as we have.

The Minor Planets. Next in order of distance, we come to the group of minor planets, or asteroids. They are exclusively telescopic objects, and require very powerful instruments to be discerned. The brightest in the group is Vesta, which appears like a star of the fifth magnitude. The dimensions of these planets, although not accurately ascertained, is comparatively small; Vesta is computed to be only 250 miles in diameter, and Pallas is supposed to be much smaller. Their orbits are much more eccentric than those of the other planets.

Jupiter. We now come to the first of a group of planets distinguished for their vast magnitudes, their rapidity of rotation, their comparative lightness, and the enormous extent of their circuits.

Next to the sun, the planet Jupiter forms the most magnificent body in our system. His great size, being nearly 1,300 times the volume of the earth, the clearness of his light, and his accompaniment of moons, render him a most agreeable object for telescopic observation. The density of Jupiter is little more than that of water, so that the quantity of matter contained in his enormous volume is only equal to about 331 times that of the earth; and it is computed that a liquid on Jupiter, which would be analogous to our oceans, would be three times lighter than sulphuric æther, and would be such that cork would scarcely float on it. The axis of Jupiter being nearly perpendicular to the plane of his orbit, there is no change in the seasons, but perpetual summer at his equator, and winter at the poles. The velocity of his rotary motion is enormous, being at the rate of 28,000 miles an hour. His day is less than ten hours; but his year is equal to nearly twelve of ours.

The belts of Jupiter are certain streaks across his disk, running parallel to his equator; they are not fixed or regular either in size or number, but are observed to vary, to run into each other, and sometimes suddenly to disappear. They are supposed to be clouds floating in the atmosphere of the planet; or rather, perhaps, the darker body of the planet appearing through the atmosphere.

The distinguishing feature of the planet Jupiter is his being accompanied by four moons, which revolve round him in periods of time varying from 1 day 18 hours, to 16 days. The moons of Jupiter form, with the planet as a central body, a planetary systam in miniature; the first and fourth are about the size of Mercury; the second and third about the size of our moon.

Saturn. This planet, the most remarkable body in the system in point of architecture, is nearly twice the distance of Jupiter from the sun; or, at the mean distance of 900,000,000 miles.

Saturn rotates upon his axis in 10 hours 29 minutes, forming his day; and completes his revolution round the sun in 29½ of our years, forming one of his. Next to Jupiter, he is by far the largest of the planets, having a diameter of 76,000 miles, and a bulk equal to nearly a thousand times that of the earth. The density of Saturn is little more than that of cork. Although never seen by us at a point nearer than 800,000,000 miles, Saturn shines to the naked eye, with a pale, feeble, yet steady light; but becomes one of the most fascinating objects in the heavens as seen with the telescope. The body of this planet is encompassed with an inner and outer ring, resembling the horizon round a globe, but at a greater comparative distance. The width of the double ring is computed at 30,000 miles; and the space between the inner ring and the body of the planet 19,000 miles. The figure of Saturn is the flattest of all the planets at the poles, for in addition to the centrifugal force generated by his rapid rotation, the attraction of the rings over the equator has aided the accumulation of matter in that region.

Saturn exhibits belts like Jupiter, indicating an atmosphere; his seasons, zones, and climates, are similar to those of the earth, and the tropical and polar phenomena are the same. Of his satellites little is known, they require very powerful telescopes to reach them.

Uranus. Since the time of the discovery of this planet by the illustrious Herschel, little has been added to our knowledge of him. He is certainly attended by at least four satellites, possibly more, and their revolutions are performed in a direction contrary to the general movements of the planetary system, from west to east; while the inclination of their paths to the ecliptic, one of which forms an angle of only 11 deg. 2 min. with a perpendicular to its plane, is another deviation from what would seem to be the existing arrangement with all the other planets, except Neptune.

Neptune. This, the most distant of the known planets in the solar system, was discovered by Messrs. Adams and Le Verrier, in 1846. He revolves at the vast distance of 2,862 millions of miles from the sun, and occupies 164 years in performing his vast circuit round that luminary, although he travels at the rate of 12,500 miles an hour. The discovery of a satellite to this remote planet is due to Mr. Lassel, of Liverpool; and it is found to travel in the same retrograde order as the satellites of Uranus.

COMETS

Besides the planets already described, there is an unknown number of other bodies, called Comets, which revolve round the sun in very elliptical orbits. Their period of revolution is so long that very little is known respecting them. They are only seen by us when they are in that part of their orbits which is nearest the sun, and then they move with such vast rapidity that they soon become again invisible to us. They are not all alike in appearance; some appear like a faint vapour, while others have a solid part in the middle. When they approach the sun, they have a tail of luminous matter, which is sometimes of astonishing length, and always directed from the sun.

The conjectures of many eminent astronomers respecting the nature and causes of the tails of comets, show that they are not yet understood. Some have thought that it was the atmosphere of the comet driven behind it by the force of the solar rays. Sir Isaac Newton considered that the tail is a thin vapour raised by the heat of the sun from the comet. Probably neither of these conjectures is right; and the nature, uses, and laws of comets are left for future discovery.

THE EARTH.

Having described the solar system, and the planets which compose it, with the exception of the Earth, we have reserved the latter, on account of its importance to us rendering it desirable to describe it in connection with the celestial phenomena with which it is associated.

The diameter of the Earth is 7,912 miles; its circumference at the equator 24,900 miles; and its mean distance from the sun 95,000,000 miles. The Earth performs its revolution round the sun in 365 days 6 hours, forming our year; and turns upon its axis in about 24 hours, producing the phenomena of day and night.

The ancients considered that the Earth was a large flat plain, surrounded by water; but what there was beyond this mass of land and water, or what there was below it, or how the Earth was supported, were problems they were unable to solve. At length men became more enquiring, and it was discovered that the earth is globular, or round; but it has been only within the last three hundred years that the true figure of the earth has been ascertained.

THE ATMOSPHERE.

The earth is surrounded on all sides by the atmosphere, which extends to the height of about forty-five miles, decreasing in density in proportion to the altitude. Among its important properties, it possesses that of Refraction; that is, a ray of light from any celestial object, in passing through the atmosphere becomes refracted, or bent out of a straight line, and is deflected towards the earth. This occurs to the greatest extent when the celestial object is near the horizon; and, as a consequence, it appears to us higher than it really is, because we see all things in the direction in which their rays last approach the eye. It is owing to this that the sun is seen some minutes before it rises above the horizon and after it has sunk below it.

DAY AND NIGHT

In order that this phenomena may be clearly understood, it must be borne in mind, first, that the earth is round; secondly, that it receives its light from the sun; thirdly, that a globe cannot be illuminated on both sides at the same time by one luminary; fourthly, that if both sides are to enjoy the light, it must be in succession; thus, while one side is enlightened, the other side must be in darkness and *vice versa.* Now, the earth has always one side dark and the other side light; and that both sides may enjoy the cheering rays of the sun, the earth is constantly revolving upon its axis, thus bringing every part of its surface, once in every twenty-four hours, under the influence of the meridian sunlight, and once into the position immediately opposite. Accordingly, while it is mid-day in England, it is mid-night on the opposite side of the globe, or in New Zealand.

THE SEASONS

The grand cause of the seasons is the inclination of the axis of the earth to the plane of its orbit, during the revolution of the globe round the sun. This inclination is to the extent of 23½ degrees, and is always preserved; the north pole of the earth being constantly directed to the same point in the heavens. In consequence of this, the north and south poles of the earth are alternately presented to the influence of the sun's light and heat; so that, when it is summer in the northern hemisphere, it is winter in the southern, and *vice versa.* We will briefly follow the earth's progress in its orbit during the different seasons.

On the 20th March the sun is vertical on the equator, his rays fall equally on the northern and southern hemispheres, and the days and nights are equal in length all over the world. This is the SPRING EQUINOX. The earth proceeds in its orbit, gradually the north pole comes more under the influence of the sun's rays, which fall more and more perpendicularly; and the length of the days exceeds that of the nights, in proportion to the distance from the equator, until the 21st June, when the sun becomes vertical at the tropic of Cancer, and we reach the SUMMER SOLSTICE. After this, the earth proceeding in its course, the north pole gradually recedes from the sun, the days shorten, the sun's rays become more oblique, and on the 23rd September the sun is again vertical at the equator, and we arrive at the AUTUMNAL EQUINOX. The earth speeds onward, the days become shorter than the nights, the sun's rays fall more and more obliquely on the northern hemisphere until the 21st December, when we reach the WINTER SOLSTICE. The north pole is now furthest inverted from the sun, which has become vertical at the tropic of Capricorn. The earth hastens on its way; our days begin to lengthen; and the sun's rays gradually increase in power. On the 20th March the sun is again vertical on the equator, and we rejoice in the return of spring.

THE MOON AND ITS PHASES.

Our satellite the Moon is a globe 2,160 miles in diameter, and revolves round the earth at a distance of 240,000 miles, in 27 days 7 hours 43 minutes and 11 seconds.

When viewed through a telescope her surface appears very bright and extremely rugged, presenting numerous mountains and deep excavations or hollows. There are no traces of water nor of an atmosphere.

The Phases of the Moon arise from the different positions which it assumes in relation to the sun and the earth during its revolution round the latter. When the moon is between the sun and the earth, its dark side is presented to us, and it is consequently invisible; in this position it is called the NEW MOON. Four days after the time of new moon it has receded 45 degrees from the sun, and now a portion of its illuminated surface is seen in the form of a crescent. After eight days it has departed 90 degrees from the sun, and shows a bright semi-circular disk; the moon is now said to be in its FIRST QUARTER. Gradually showing more of its illuminated surface, it becomes gibbous; and about fifteen days after the time of new moon, it stands directly opposite the sun, presenting a complete circular disk; this is the FULL MOON, rising when the sun sets, and shining through the whole night. Proceeding in its course, its illuminated surface gradually decreases; approaching the sun it becomes a second time gibbous; a half-moon at its LAST QUARTER; assumes a crescent form; and completing its orbit, disappears; becoming a new moon again as at first.

ECLIPSES.

When an heavenly body is darkened by the shadow of another heavenly body falling upon it, that heavenly body is said to be eclipsed.

ECLIPSE OF THE MOON. An eclipse of the moon is caused by the earth so coming between the sun and moon as to prevent the sun's rays falling upon the latter; this can only happen at the time of full moon. If the moon's orbit were parallel to the plane of the ecliptic, we should have an eclipse of the moon every month, at the time of full moon, and one of the sun at the time of every new moon; but this does not happen because the two orbits cut or intersect each other, and the moon's orbit is inclined 5 degrees 8 minutes to the plane of the ecliptic. Those two places where the intersection takes place are called the nodes; and an eclipse can only take place when the sun, earth, and moon, are in conjunction (or in a line) at the time when the moon is in one of the nodes.

ECLIPSE OF THE SUN. An eclipse of the sun is caused by the moon so coming between the sun and the earth as to prevent the rays of the former from falling on certain portions of the latter. This occurrence can only happen at the time of new moon, and when she is at or near one of her nodes.

There is a great difference between an eclipse of the sun and eclipses of the moon The light which the moon' supplies is borrowed from the sun, and when she is eclipsed it is because the earth intercepts the sun's rays, and she is in darkness; but when the sun is eclipsed, he is still shining in all his splendour; so that what is termed an eclipse of the sun, is in reality an eclipse of the earth, caused by the moon passing over the sun's disk, and thereby preventing his rays of light falling on a portion of the earth. The moon being smaller than the sun, casts a shadow which ends in a point; and, therefore, solar eclipses can only be seen by those who are within the shadow of the moon at the time the solar eclipse takes place.

THE TIDES

The tides are certain movements produced in the waters which in part surround the earth, by the attraction of the sun and moon, particularly the latter, upon them.

The waters immediately *beneath the moon* being attracted by her, are elevated into a swell, or wave of high water; at the same time, the waters on the *opposite side of the globe* are also raised into a similar swell. owing to the attraction of the moon upon the solid mass of the earth, tending to draw it away from the waters on the opposite side. Simultaneously, also, the waters between the tide swells are correspondingly depressed, that is, it is there low water. Now, as the moon is constantly revolving round the earth, so the waters follow her attractive influence; and thus we have two tides daily, at intervals of about 12½ hours.

Tides are distinguished into *neap tides* and *spring tides;* the difference may be thus explained: sometimes the sun and moon are acting in conjunction, at other times in opposition. Thus, at the time of new moon and full moon, the sun and moon are in conjunction, when their combined attraction causes the waters to be more elevated, and we have what are called *spring tides.* Again, at the times of half-moon, the sun and moon are in opposition, when we have but a slight elevation of the waters, termed *neap tides.*

THE FIXED STARS.

Vast as the solar system we have been considering may appear, it is but a mere point in the map of creation. When we pass from the planetary system to the other regions of creation, we have to traverse in imagination a space so immense, that it has hitherto baffled all the efforts of science to determine its extent. In these remote and immeasureable spaces are placed those beautiful luminous bodies, the Fixed Stars, each of which is equal or superior in magnitude and brilliancy to our sun. The grandeur of the universe thus disclosed overwhelms the mind, and its powers fail to comprehend the immensity of space, filled as it is with system after system in apparently endless succession.

The stars are divided into classes, according to their apparent magnitude, ranging from the first to the sixteenth; but all after the sixth magnitude are invisible to the naked eye. The stars have, however, no appreciable magnitude at all, remaining mere points of light under the greatest telescopic power. They vary simply in brightness. To facilitate reference to the heavens, the stars have been arranged into groups, or constellations, of which there are 35 in the northern hemisphere, and 46 in the southern. Ursa major is the most conspicuous and well known of the northern constellations. Ursa minor is important from including the north polar star. Of the southern constellations. Orion, with the groups in his vicinity, constitute the richest part of the visible heavens; Canis major, on the south-east of Orion, contains the beautiful star Sirius. The constellation of the Cross, not visible in our latitude, is important to the mariner as indicating the direction of the south pole.

Astronomers have endeavoured to ascertain the approximate distance of the fixed stars. Professor Bessel made very careful observations of a star in the constellation of the Swan, and the result was, that although the earth is distant in July 190 millions of miles from the place it occupied in January, yet the difference in the angular bearing of the same star, observed at the two periods, was somewhat less than one-third of a second. Its distance, consequently, could not be less than sixty-two billions, four hundred and eightly one thousand, five hundred millions of miles; a space which light, that flies to us in eight minutes from the sun, would require more than ten years to traverse.

In a number of instances, stars, whose places have been registered in the catalogues, have subsequently disappeared. Some stars, on the other hand, appear to be new, as no entry of them is found in the catalogues of former observers. There are also temporary stars, which appear, and after shining with more or less lustre for a time, vanish. Lost, new, and temporary stars, are among the mysteries of nature. Some astronomers suppose that these stars are subject to a periodical translation from the depths of space, moving in vast elliptical orbits, at one extremity of which they become visible to us, and then retire from view.

Versatile stars are such as undergo periodical mutations, regularly waxing and waning. These singular appearances are accounted for by supposing a rotating body to have one of its hemispheres less luminous than the other, and which, being presented to us in the course of rotation, produces the periodical changes observed.

Multiple stars are also observed; that is, stars which appear to the naked eye to be single objects, are found by the telescope to be compound, consisting of two or more individuals. They appear to be suns revolving round a common centre, each having probably its system of planets and satellites; but which, owing to their enormous distance from us, are crowded into a space which a grain of sand would cover.

NEBULÆ. Under this term are comprised a class of objects which seem to the naked eye patches of luminous matter, but which are resolved by powerful telescopes into clusters of stars, the individuals of which may be reckoned by thousands. Of such clusters of stars, there are hundreds of various shapes, each constituting as rich a firmament as that immediately around us.

The Milky Way, which stretches across the heavens, is a wonderful system of nebulæ, or stars, of which our sun is considered to form an individual member. Of this remarkable belt, Sir William Hershel says, "when examined through powerful telescopes, it is found to consist entirely of stars, scattered by millions, like glittering dust, on the black ground of the general heavens."

In concluding our rapid sketch of popular Astronomy we would strongly recommend to all the study of this great science, tending as it does to elevate the mind and impress it with more exalted ideas of the glorious Creator of all things. In the sacred writings we find frequent allusions to this sublime subject. "The heavens," says the Psalmist, "declare the glory of God, and the firmament showeth his handywork." "Lift up your eyes on high, and behold, who hath created all these things —the everlasting God, the Creator of the ends of the earth, who fainteth not, neither is weary; there is no searching of His understanding. He bringeth out their host by number, and calleth them all by names, by the greatness of His might, for He is strong in power. It is He that sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers; all nations before Him are as nothing; and they are counted unto Him less than nothing and vanity."

We should not only study God in the revelation he has made of himself in the Scriptures; but we should also study him as he unfolds his glorious attributes in the works of creation. They are both revelations of the same almighty and benevolent being; both are in perfect harmony with each other; both display His power, His wisdom, and His love.

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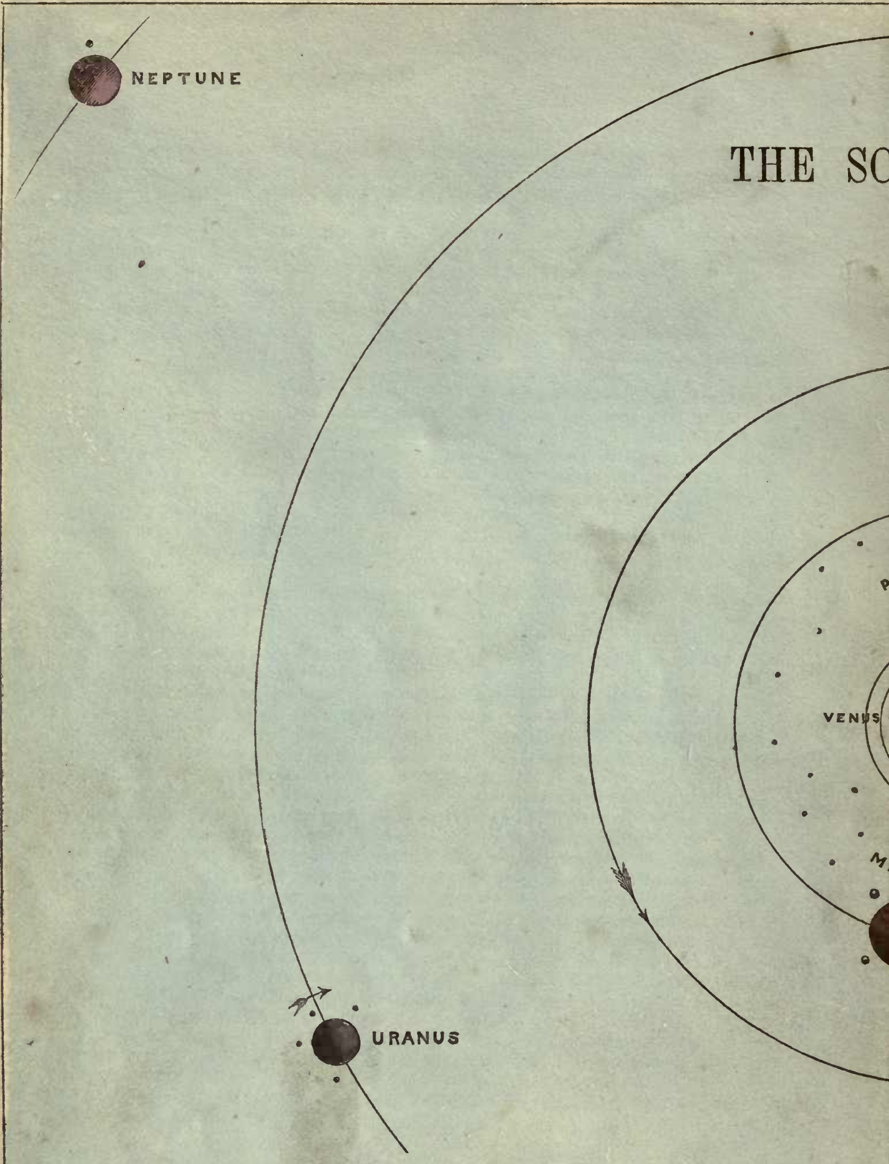

PRINCIPAL PLANETS, and their Mean Distance from the Sun in Millions of Miles.		Period of Revolution in Days.	Hourly Motion, Miles.	MINOR PLANETS Date of Discovery, and Discoverer.	Period of Revn. Days.
MERCURY	37	88	110,000	Ceres, 1801, Piazzi	1,680
VENUS	69	225	80,000	Pallas, 1802, Olbers	1,686
EARTH	95	365	68,000	Juno, 1804, Harding	1,592
MARS	145	687	55,000	Vesta, 1807, Olbers	1,326
JUPITER	496	4,332	30,000	Astrea, 1845, Hencke	1,511
SATURN	909	10,759	22,000	Hebe, 1847, Hencke........	1,380
URANUS	1,828	30,687	16,000	Iris, 1847, Hind	1,346
NEPTUNE............	2,862	60,126	12,500	Flora, 1847, Hind..........	1,193
				Metis, 1848, Graham	1,347

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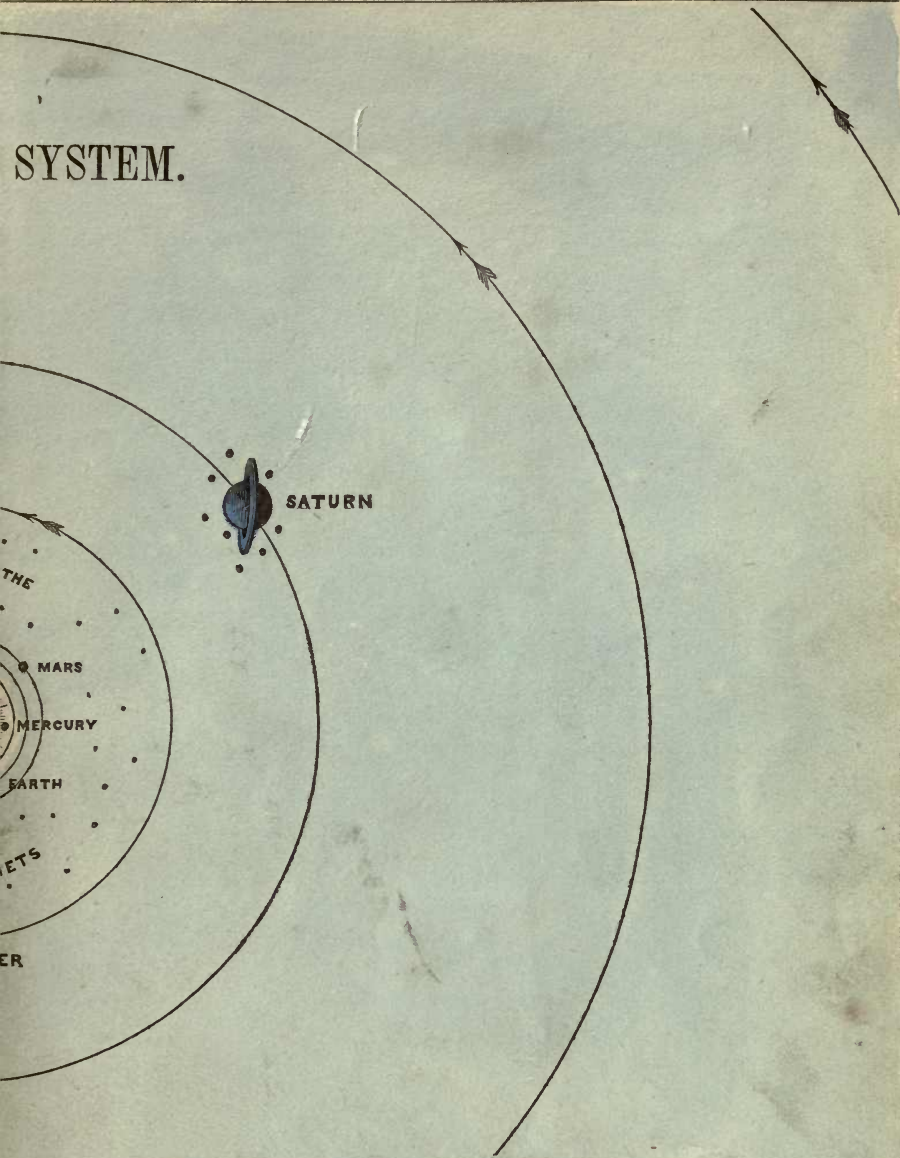
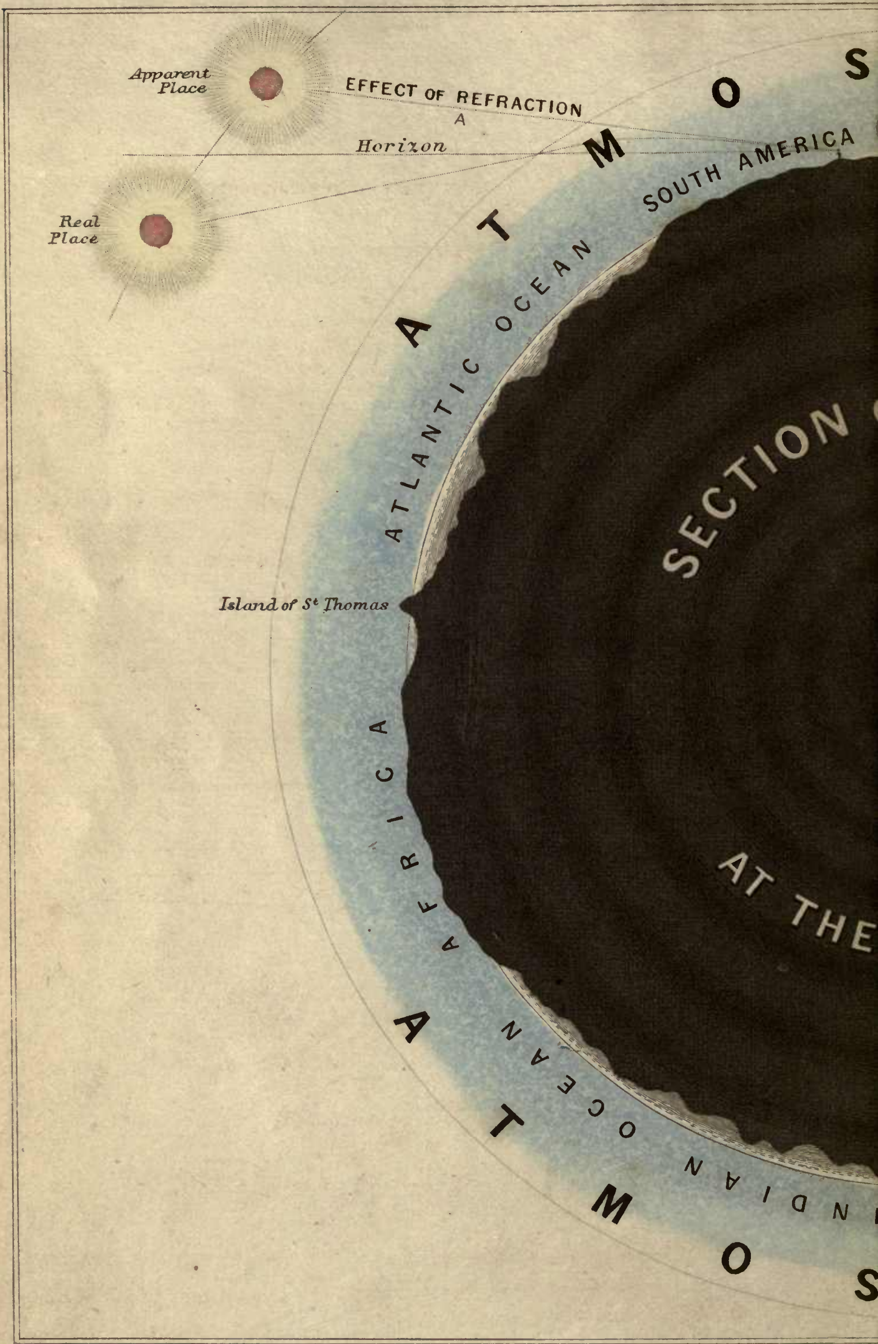
SYSTEM.



ANETS, very, and rer	Period of Revn. Days.	MINOR PLANETS, Date of Discovery, and Discoverer.	Period of Revn. Days.	MINOR PLANETS, Date of Discovery, and Discoverer.	Period of Revn. Days.
sparis	2,041	Fortuna, 1852, Hind.........	1,395	Bellona, 1854, Luther	1,689
), Gasparis..	1,402	Massilia, 1852, Gasparis	1,364	Amphitrite, 1854, Marth....	1,491
ind.........	1,300	Lutetia, 1852, Goldschmidt..	1,388	Urania, 1854, Hind	1,350
sparis	1,512	Calliope, 1852, Hind........	1,817	Euphrosyne, 1854, Ferguson	2,047
l..........	1,518	Thalia, 1852, Hind..........	1,554	Pomona, 1854, Goldschmidt.	1,512
Gasparis....	1,570	Themis, 1853, Gasparis......	2,037	Polyhymnia, 1854, Chacornac	1,787
sparis.	1,825	Phocea, 1853, Chacornac....	1,359	A Planet, 1855, Chacornac..	
ther	1,421	Prosperine, 1853; Luther....	1,581	Lencothea, 1855, Luther....	
. Hind.....	1,271	Euterpe, 1853, Hind	1,311		

EYNOLDS, 174, STRAND.

THE EARTH AND



Drawn and Engraved by John Emslie.

EX

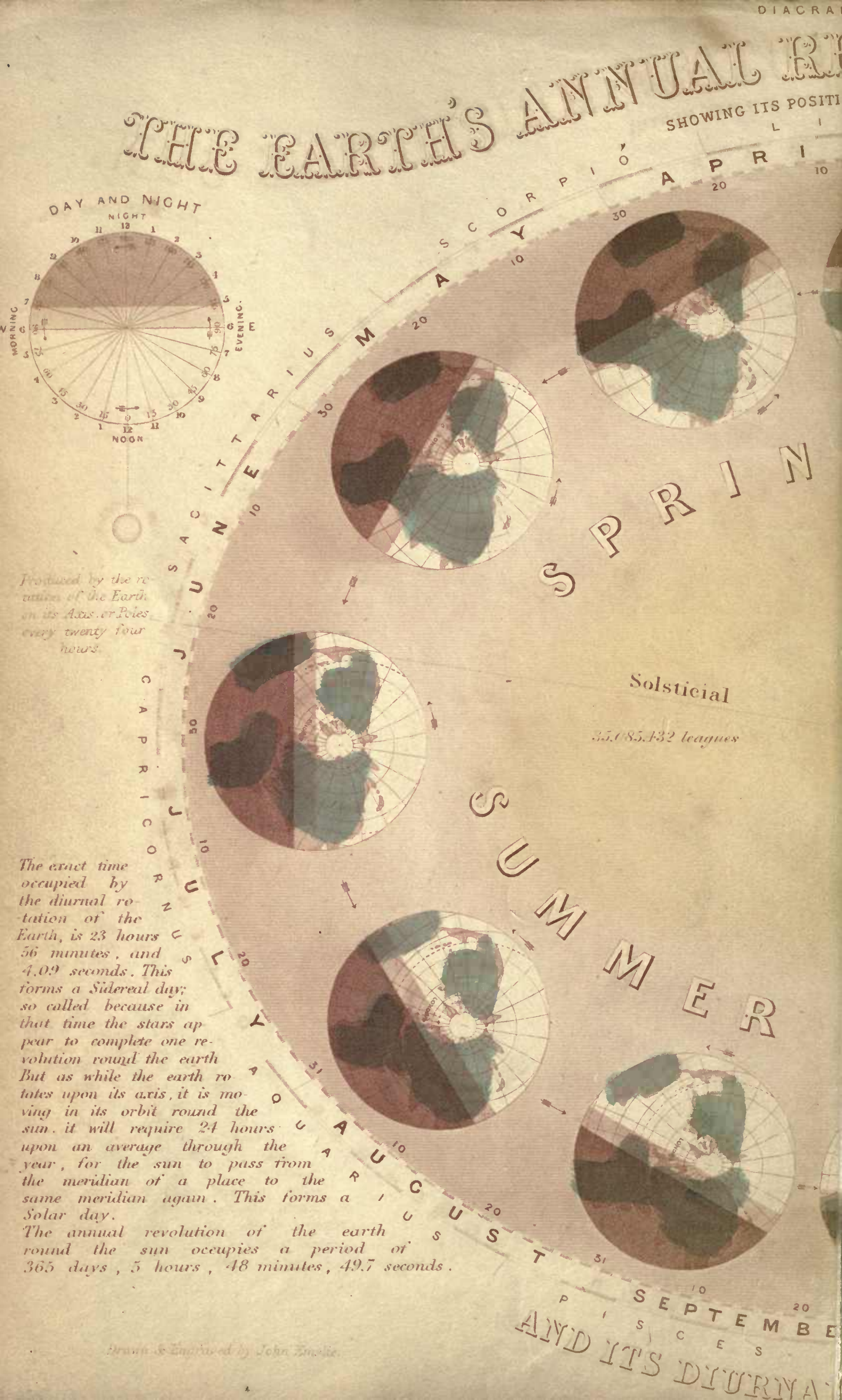
The Earth *is 24,912 miles in circumference, and 7,926 miles in diameter at the equator. Its surface conta*
greatly, the inequality of its bed being fully as great as the inequality of the surface of the land.
The surrounding Atmosphere extends from the surface of the Earth, where it is most dense, to th
its numerous other important qualities, it possesses the power of refraction, illustrations of which are show
other the refractive effects at sea in particular states of the atmosphere.

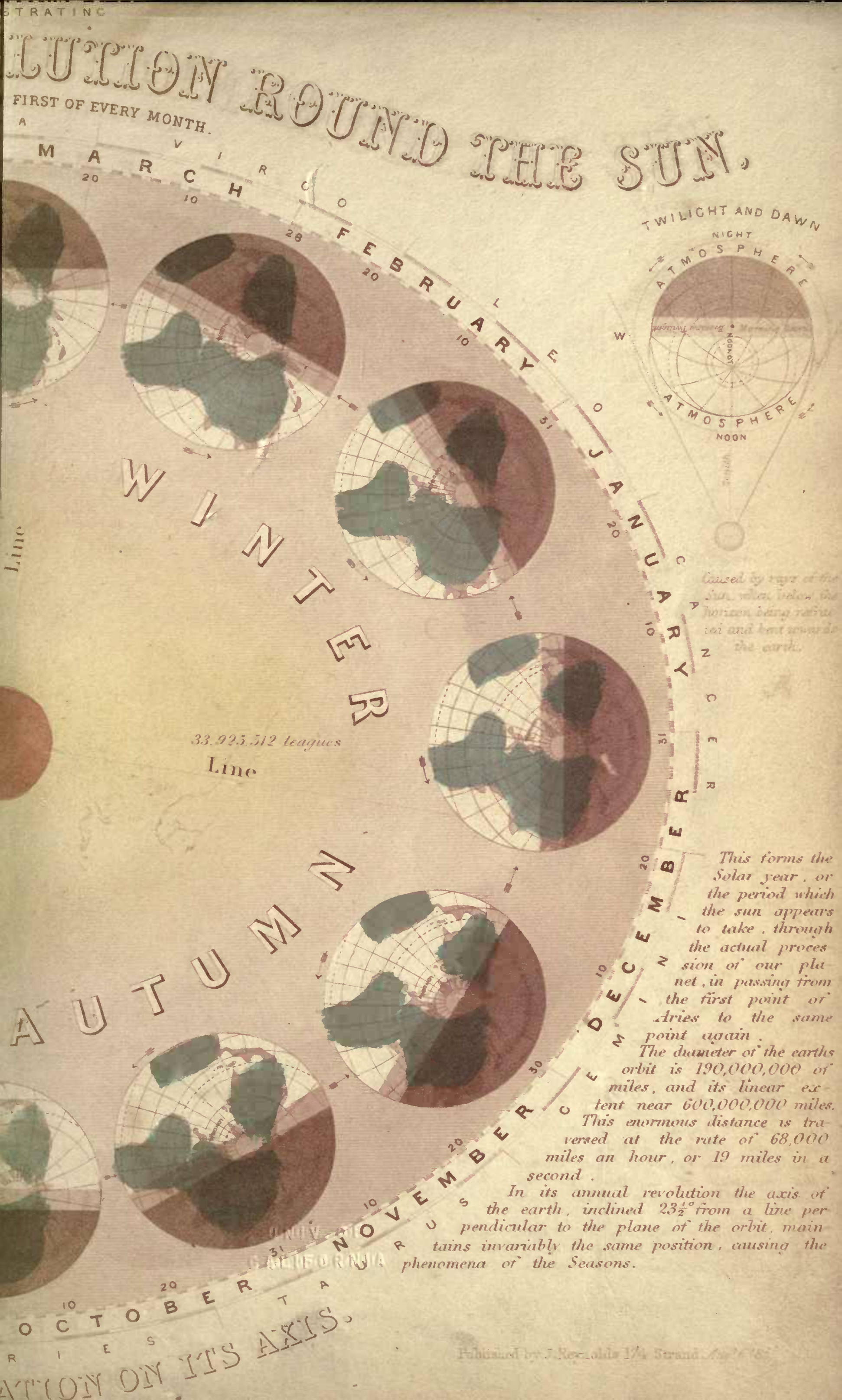
S ATMOSPHERE.

Published by James Reynolds 174 Strand. March 10th 1849

v

ns of square miles of water, and 49 millions of square miles of dry land. The depth of the ocean varies
of the Earth, beyond a few hundred feet from its surface, nothing is known.
out 45 miles. At the height of a few thousand feet it becomes too rarefied to support life. In addition to
and B; the first showing how a spectator observes the sun, while that body is yet below the horizon, the


DIAGRA
THE EARTH'S ANNUAL R
SHOWING ITS POSITI
DAY AND NIGHT
NIGHT
MORNING
EVENING
NOON
Produced by the rotation of the Earth on its Axis or Poles every twenty four hours.
SCORPIO
SAGITTARIUS
CAPRICORNUS
AQUARIUS
PISCES
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBE
SPRING
SUMMER
Solsticial
35,085,432 leagues
The exact time occupied by the diurnal rotation of the Earth, is 23 hours 56 minutes, and 4.09 seconds. This forms a Sidereal day; so called because in that time the stars appear to complete one revolution round the earth But as while the earth rotates upon its axis, it is moving in its orbit round the sun, it will require 24 hours upon an average through the year, for the sun to pass from the meridian of a place to the same meridian again. This forms a Solar day.
The annual revolution of the earth round the sun occupies a period of 365 days, 5 hours, 48 minutes, 49.7 seconds.
AND ITS DIURNA
Drawn & Engraved by John Emslie.


STRATING
LUTION ROUND THE SUN.
FIRST OF EVERY MONTH.
MARCH
FEBRUARY
JANUARY
DECEMBER
NOVEMBER
OCTOBER
VIRGO
LEO
CANCER
TAURUS
ARIES
WINTER
AUTUMN
33.925.512 leagues
Line
Line
TWILIGHT AND DAWN
NIGHT
ATMOSPHERE
ATMOSPHERE
NOON
W
Caused by rays of the Sun, when below the horizon being refracted and bent towards the earth.
This forms the Solar year, or the period which the sun appears to take, through the actual procession of our planet, in passing from the first point of Aries to the same point again.
The diameter of the earths orbit is 190,000,000 of miles, and its linear extent near 600,000,000 miles. This enormous distance is traversed at the rate of 68,000 miles an hour, or 19 miles in a second.
In its annual revolution the axis of the earth, inclined 23½° from a line perpendicular to the plane of the orbit, maintains invariably the same position, causing the phenomena of the Seasons.
ATION ON ITS AXIS.
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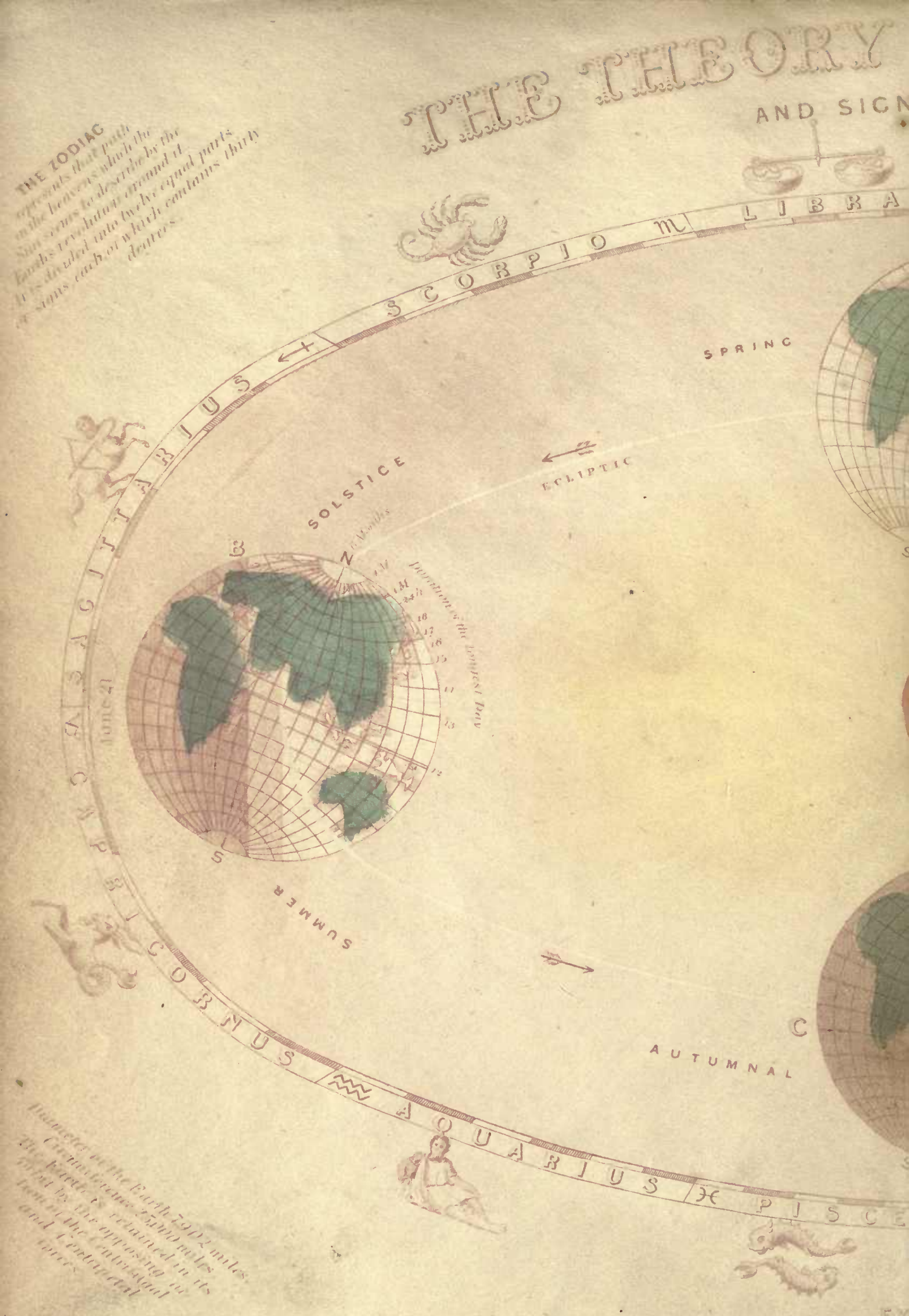


EX

THE PHENOMENA OF THE SEASONS is occasioned by the annual motion of the Earth in its orb
On the 20th March the Earth is in the position A when one half of the globe is illuminated from pole
comes into the position B the inhabitants of the Northern Hemisphere enjoy summer on account of the
they are more distant from the Equator and those within the Polar Circle have constant daylight
proportion as they are further from the Equator. Those within the Polar Circle have constant night
then again equal all over the world. After this the Earth advances to the position D and the inhab

London

ON.

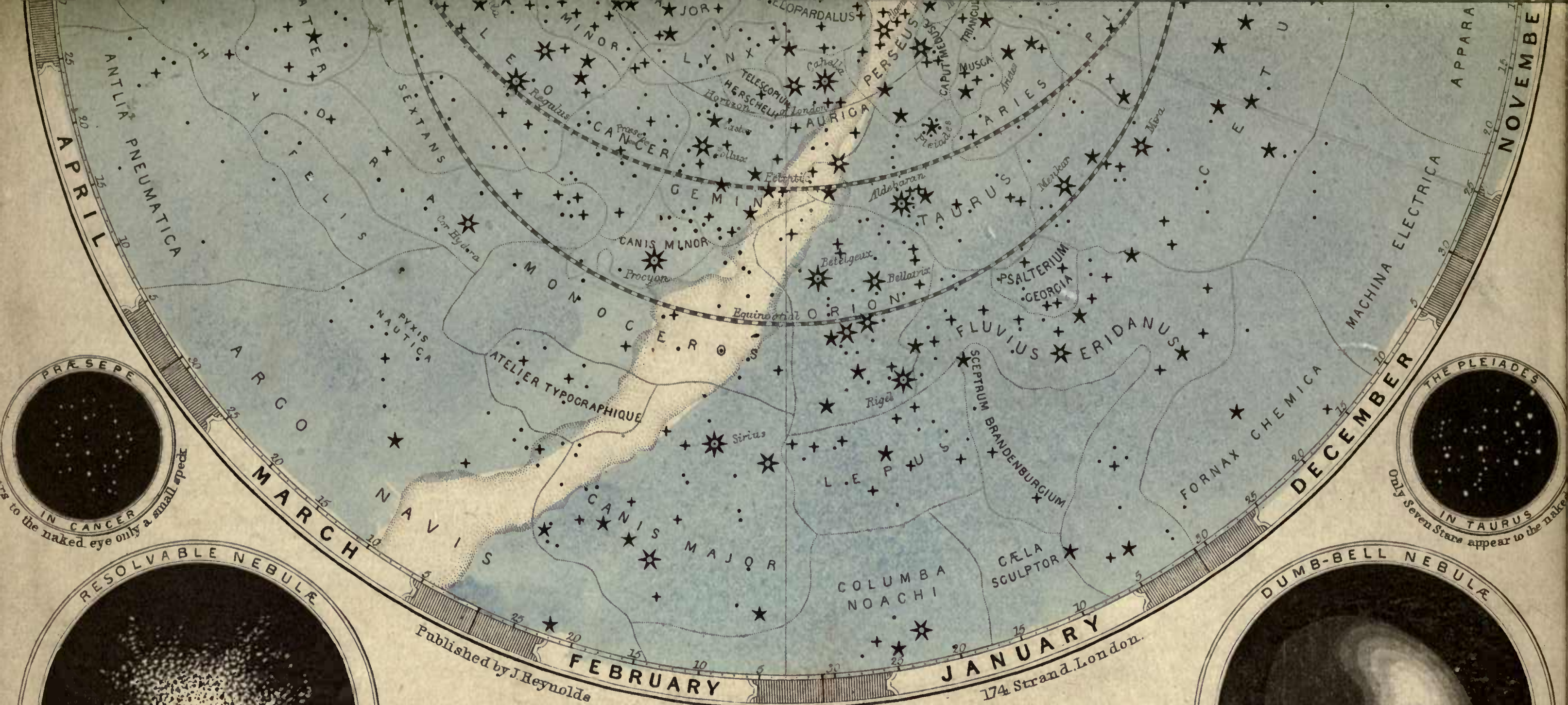
…ted above the Axis or Poles of the Earth being constantly directed towards the same point in the heavens
…re the days are of equal duration with the night all over the world. As the Earth proceeds in its Orbit…
…alling more perpendicularly upon them they have also their days longer than their nights in proportion…
…ng the inhabitants of the Southern Hemisphere have winter their days being shorter than their nights…
…h continues in its course, and on the 23rd September arrives at the position C the days and nights are…
…he Northern Hemisphere have winter

17 Strand

TRANSPARENT CHART OF THE HEAVENS,

For the Latitude of Great Britain.

SHEWING THE STARS VISIBLE ON ANY NIGHT THROUGHOUT THE YEAR.



Published by J. Reynolds 174 Strand, London.

MAGNITUDES 1st ✵ 2nd ✲ 3rd ★ 4th + 5th ·· OF THE STARS

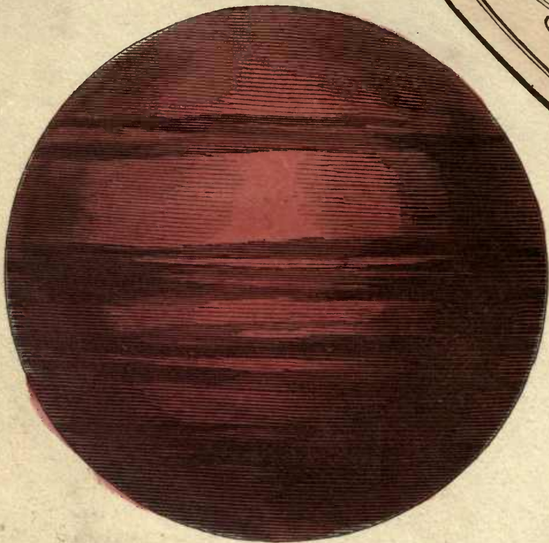
DIRECTIONS

Find the day of the Month on the outer circle and the stars in a straight line with it, and the Pole-star in the centre will be on the meridian, or south, at nine o'clock in the evening, the relative positions of the other stars and constellations may then be readily traced.

Nebulæ of which a few representations are here given, are considered to be siderial firmaments each as expansive as that surrounding our system, but compressed by their immeasurable remoteness into a space, which at the largest to the naked eye, a snow-flake will utterly conceal.

The comparative diameter of the Sun upon this scale will be two feet four inches.

COMPA



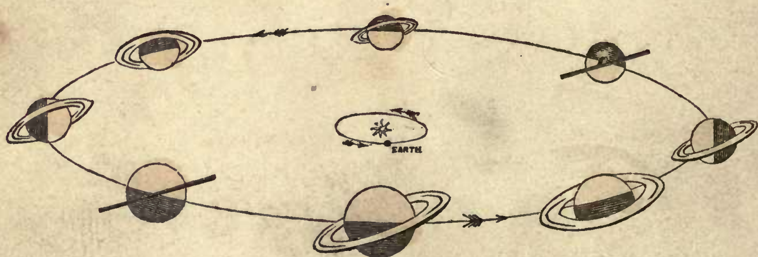
JUPITER

SAT

DIAMETER OF T

JUPITER 89,000. SATURN 76,000. NEPTUNE 75.500. URANUS 35,00

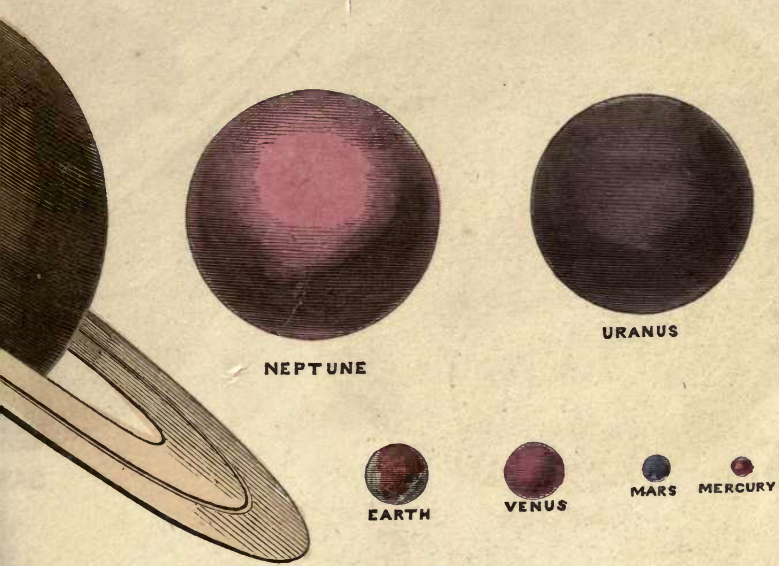
PHASES OF SATURN.



The planet Saturn presents various appearances to the earth, consequent upon the relative positions of the two bodies. Thus, while the planet traverses one part of its orbit, the southern side is presented to us, and during its passage through another portion of its orbit, the northern side is seen. Twice in every revolution, or once in every fifteen years, the plane of the ring intersects the ecliptic, and its edge is then seen as a fine line across the body of the planet; at other parts of the orbit the ring becomes more or less open as the planet recedes from, or approaches, the points of intersection.

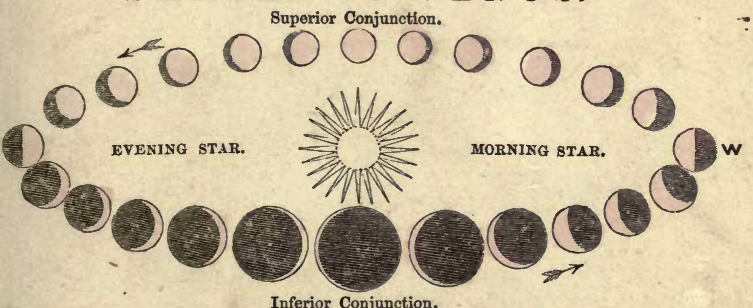
LONDON: PUBLISHED BY

E MAGNITUDES OF THE PLANETS.



IN MILES.
EARTH 7,912. VENUS 7,800. MARS 4189. MERCURY 3,140.

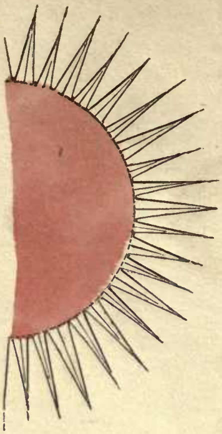
PHASES OF VENUS.



'he brilliant and beautiful planet Venus, during its annual revolution round the presents to us phases similar to those of the moon, as represented in the diagram. ing her conjunction she is generally invisible; but after passing ner inferior con- tion, she appears west of the sun as a morning star; and after passing her superior unction, she is seen east of the sun as an evening star. Her apparent magnitude es according to her distance from the earth, which at her inferior conjunction is only nillion miles, but at her superior conjunction 160 millions.

NOLDS, 174, STRAND.

The Phases of the Moon arise from the different positions it assumes in relation to the sun and the earth, during its revolution round the latter. When the Moon is between the sun and the earth, its dark side is presented to us, it is then invisible, and is called the New Moon; proceeding in its orbit, a portion of its illumined surface becomes visible in the form of a crescent;



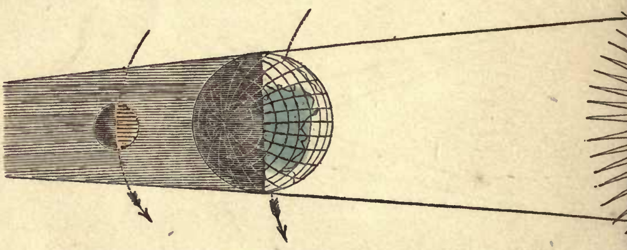
THE

PHAS

OF THE

MOO

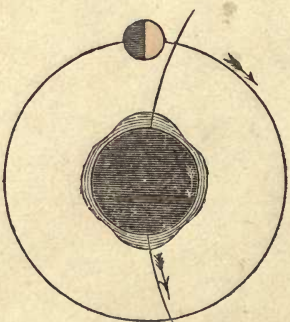
Eclipse of the Moon. An eclipse of the moon is caused by the earth coming between the sun and the moon, so as to prevent the sun's rays falling upon the latter; this can only happen at the time of full moon, and when the sun, earth, and moon, are in conjunction, at the time when the moon is in one of the nodes.



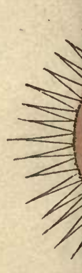
ECLIPSE OF THE MOON

EC

The Tides are caused by the attraction of the sun and moon upon the waters of the earth. Neap Tides are occasioned by the attraction of the moon alone; the waters immediately beneath the moon being elevated into a swell or tide wave, follow her attractive influence, as she revolves round the globe. The second tide on the opposite



NEAP TIDES.



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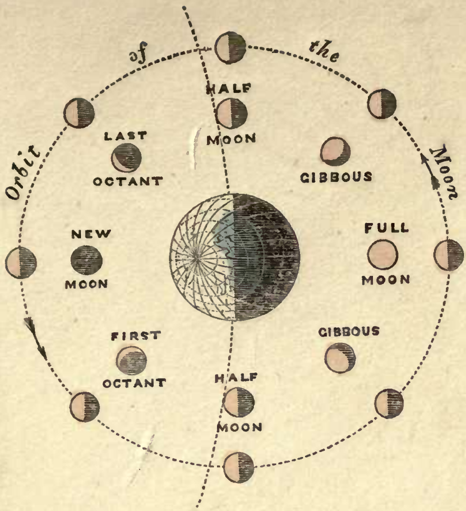
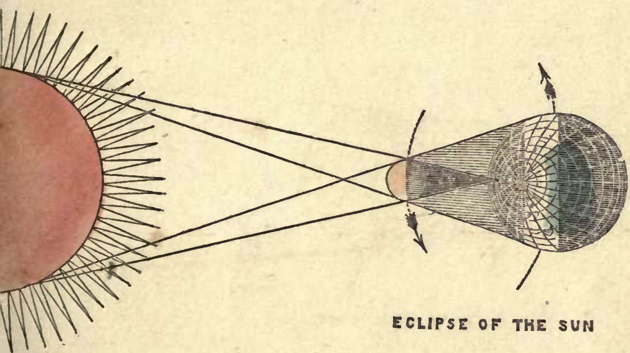


then a half moon; three quarters full; and, lastly, the moon attaining a position opposite to the sun, its whole illumined disk is presented to the earth, when it is called a FULL MOON; Advancing onwards in its orbit, its illumined surface is gradually inverted from the earth, until it entirely disappears, and the Moon bacomes invisible, as at first.

Eclipse of the Sun.

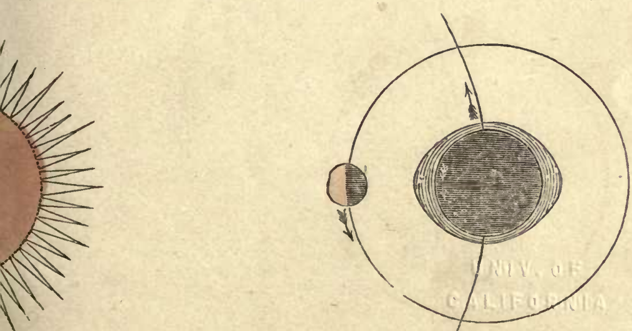
An eclipse of the sun is caused by the moon so coming between the sun and earth, as to prevent the rays of the former from falling on certain portions of the latter. This phenomenon can only happen at the time of new moon, and when she is at, or near, one of her nodes.



ECLIPSE OF THE SUN

ES.

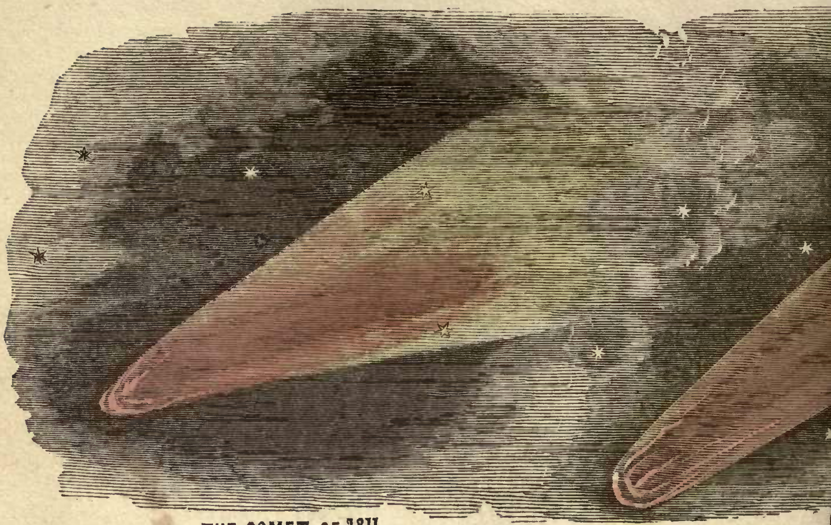
side of the globe is caused by the moon attracting the solid body of the earth away from the waters on that side, causing them to be elevated into a similar swell. Thus we have two daily tides. SPRING TIDES occur from the combined influence of the sun and moon when they are in conjunction, causing the tides to be more elevated.



SPRING TIDES.

S.

COMETS, AEROLITES.

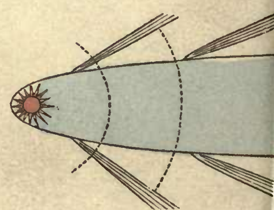


THE COMET OF 1811

Comets are heavenly bodies of a luminous and nebulous appearance, which approach to a
recede from the sun, moving in very elliptical orbits; they usually present the following ph
nomena. A faint luminous circle is first seen by the aid of good telescopes, after a short ti
a nucleus or part where the light seems more concentrated appears, the object continues
enlarge, and a tail begins to form which looks as if one side of the nucleus were projected in
stream of light away from the body of the comet. This tail increases in length, so as sometim
to spread across the whole visible heaven. The comet approaches the sun, and passing rou
it, is for a time lost to view, but emerges again on the other side with increased brilliancy. T
phenomena of disappearance are then in the inverse order, the same as those of its appearan

AEROLITES.

Aerolites. These are supposed to be small bodies moving in space, and which are occasionally met with and attracted by the earth. Their luminous appearance is owing to their becoming ignited by the intense heat acquired by their great velocity and the compression of the air. The view represents a shower of Aerolites seen in Europe in 1835.



ELLIPTICAL

Cometary Motion. It
about the sun in orbits of a
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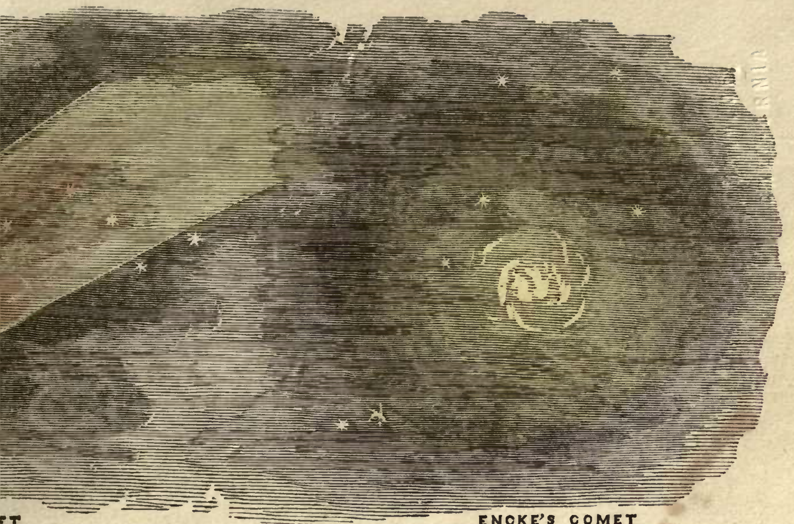
form, although of various deg
comet in its orbit, varies wi
rapid when near that lumina
from him. At different par
passage, showing the directio
be opposite to the sun.

LONDON: PUBLISHED

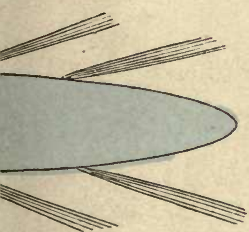
) ZODIACAL LIGHT.



ET

ENCKE'S COMET

Diagram represents three Comets of modern times. First, the celebrated Comet of 1811,
ı had a tail computed to be 123 millions of miles in length, by a breadth of 15 millions;
which, according to the calculations of Bessel, will not repeat its visit till the year 5194.
.ey's Comet, whose last appearance was in 1835, has a period of about 76 years. This
t has undergone remarkable changes in appearance. In 1456 it passed near the earth, with
extending over 60°. Its later appearances have been much less conspicuous. Encke's
ɪt, is a small comet which revolves round the sun in about 1210 days, within the orbit of
er. It has no nucleus, or tail, but resembles a globular patch of vapour, and seems to be
asing in brightness.



COMET.

en stated, that comets move
n, of which the longer dia-
l having the sun noar one
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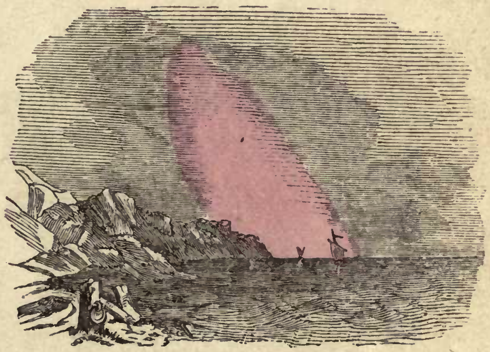
from the sun; inconceivably
in proportion to its distance
, a comet is indicated it its
ı every part of its course, to



THE ZODIACAL LIGHT.

The Zodiacal Light is a luminous phenomenon occasionally seen in the heavens. Its figure resembles an inverted cone, having its base towards the sun, and its axis lying along the zodiac. It is generally of a delicate rose tint, and is most favourably seen early in March, shortly before sunrise or after sunset.

ɴOLDS. 174. STRAND.

PICTORIAL

AND

DESCRIPTIVE ATLAS

OF

GEOLOGY.

ILLUSTRATING THE PRINCIPLES OF THIS
IMPORTANT SCIENCE.

REVISED

BY JOHN MORRIS, F.G.S.

LONDON: JAMES REYNOLDS, 174, STRAND.

POPULAR GEOLOGY.

Geology is a branch of science which investigates both the ancient natural history and physical condition of the earth's crust; treats of the successive modifications it has undergone; and the agencies which even now are producing changes on the surface of the globe. Palæontology, which specially treats of the history and affinities of those animals and plants whose remains occur in the various strata; and Mineralogy, which treats of the composition and actual nature of the materials composing the various rocks and strata, are intimately connected with geology.

The crust of the earth, up to the altitude of 24,000 feet, and down to depths of 3,000 feet, has in every direction of its accessible parts been investigated, and sufficient is known of its structure to warrant the assumption, with tolerable certainty, of the following important principle:—*The crust of the earth consists of only a proportionably small number of different rocks, and these are similar to each other at the most distant parts of the globe, as to their principal mineral characters.* Thus the various kinds of rock are distributed over the entire globe, the granites of South America and of the most northern climates are nearly alike; while on the other hand, plants and animals of the equator, of the temperate zones, and of the polar circles, exhibit the most striking differences.

Heat of the Globe. The temperature of the globe is an important element in the history of the changes which the earth has undergone. At each point of the earth's surface there is a certain mean temperature; but beneath the surface, observations show that a continual augmentation of temperature proportioned to the depth constantly occurs. It is hence concluded, that the interior parts of the globe are incomparably hotter than the parts at the surface; must formerly have been still hotter, and have influenced to some extent the temperature and all the other phenomena at the surface of the earth. That the internal heat was once greater than it now is, is evident from many facts. The deepest rocks are such as appear evidently to have been cooled down from igneous fusion; and the figure of the earth is such as would result from revolution on its axis, provided the whole or a large part of its mass were in a state of fluidity or viscidity.

Modern causes of Change. Besides the changes resulting from the gradual cooling of the mass of the earth, there are many other forces now in action tending to produce changes in the external crust of the globe. The varying heat received from the sun; the effect of heat and physical condition in modifying the animal and vegetable world; the disintegrating effect of seas, rivers, springs, and rain; the chemical and mechanical action of the atmosphere; the disruptive forces of volcanoes and earthquakes; the sediments transported by rivers; the formations due wholly to the labours of innumerable marine animals; the effects of frost, glaciers, and icebergs—all tend to produce incessant change on the earth's surface. These changes affect the geographical boundaries of land and water, the relative levels of land and sea, and the forms, proportions, and distribution of organic life.

The statement of the effects of modern causes of change on the earth's surface is also applicable to former eras of the world, at least in its general features; but they may not always have been equal in degree of action. Many sudden changes have evidently occurred, arising from the unusual predominance of some of the above forces.

Successive Periods of Formation. At a certain depth below the surface of the earth the rocks are massive, without stratification, and without fossils, affording evidence of having been acted on by heat; but above these rocks are others which, by being stratified, and by having fossils peculiar to themselves, may be classified and arranged. They represent too, epochs of time, in respect to their period of formation, although we are unable to measure that time by years or centuries.

The rocks composing the earth's crust may be classified in various ways. Looking merely at the formation of the rocks, we may distinguish Stratified and Unstratified rocks. If we consider whether remains of plants or animals have been found in the deposits, we may distinguish Fossiliferous and Unfossiliferous rocks. Lastly, if we consider the agencies which have been at work in producing the different rocks, we may distinguish them into three groups, viz., the Igneous, Metamorphic, and Aqueous formations. The first have been produced by the fusion of mineral matters by the action of heat; the second, by the action of heat in modifying previously deposited rocks; and the last have for the most part been deposited in strata at the bottom of seas, rivers, and lakes. The aqueous rocks have been divided into three great series, chiefly in reference to their organic contents, viz., the Palæozoic series, or Primary; the Mesozoic, or Secondary; and the Cainozoic, or Tertiary. These several series, with the groups they include, will be found stated at length on the Table of Geological Strata, forming one of the plates of the Atlas. The Igneous, Metamorphic, and Fossiliferous rocks also, are described upon the several Diagrams illustrating them.

Present Aspect of the Globe. The outlines of land and sea throughout the globe depend principally on the disposition and groups of mountain chains, which in every instance yet known, are certainly shown to have been raised by mechanical agency, generally the result of igneous action. Frequently, however, this dependence of the form of the existing land upon the ranges of mountains is disguised by the extent of comparatively plain country which separates the mountains from the sea. In such cases, it is necessary to admit that the general level of the sea has subsided, or that large tracts of land have been raised gradually, or by successive movements around the mountains, which in earlier times may have been uplifted by more violent causes.

The interior features of every country in like manner depend upon recognized geological agencies. The unequal elevation of mountain ranges above the sea is a phenomenon wnich will be found of great importance in geological theory. It appears to be true, at least in Europe, that the most elevated chains of mountains are those whose elevation was not completed until the tertiary or later epochs. Raised in this manner by violent or gradual movements out of the sea, the dry land has since been subjected to waste by atmospheric action. The formation of valleys is due to the various effects of atmospheric agency; the action of running waters; the subsidence of the crust of the earth; dislocations on the line of the valley; or by the overwhelming force of a general flood. The forms of hills, like the depth and direction of valleys, are in part dependent on the presence of strata of unequal resisting power.

The land visible on the surface of the globe is not all of the same antiquity; some regions must have been covered with trees, and traversed by animals, before the substance of others was laid on the bed of the sea. Since life was developed on the globe, there appears never to have been any considerable period during which the land or sea was wholly deprived of organic beings; but as the condition of the globe changed, the forms of life were altered, old races perished, new creations were awakened, the sum of animal and vegetable existence was continually augmented, and the variety of their forms and habits continually multiplied, until man was added to the wonders of creation.

Economic Geology. As geology advances, its application to productive industry becomes more and more valuable. The great aid afforded by this science to coal mining has been shown, in indicating where coal may or may not be reasonably looked for, according to the nature of the adjacent strata. Of the situation of metallic treasures, enough is known to show that the occurrence of mineral veins is a circumstance depending on conditions which are more or less ascertainable. In planning the lines of railways, canals, &c., the engineer will often be benefited by the records of geological surveys. The careful researches preparatory to the selection of stone for the new Houses of Parliament, afford an example of the way in which geology may be brought to bear on the constructive arts, as indicating the position, character, and extent of the different marbles, limestones, clays, &c. To the agriculturalist, geology has rendered some services, and probably may in future be appealed to for further aid. Geology is the basis of all sound knowledge for ascertaining the position of springs and the subterranean distribution of water. The rain which falls upon all soils and rocks indifferently, runs off the clays, but sinks into the limestones, sandstones, and other rocks, whose open joints act like so many hidden reservoirs Hence, a knowledge of the subsequent course of these waters is of infinite importance to the subject of drainage, the construction of wells, and to the supply of water to towns.

(In part abridged from an able article in the National Cyclopædia.)

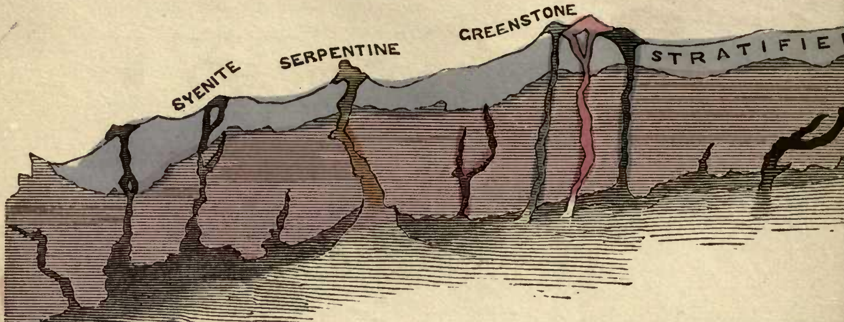
GEOLOGICAL M

OF THE WORLD.

by John Emslie

d, Gravel
t, Crag, Clay
lk, Oolite Red Sandstone
l, Limestone, Devonian
a, Gneiss, Quartz, Granite
p, Greenstone, Porphyry
Coal has been found

Cape Pillar, Van Dieman's Land.
A remarkable basaltic formation.



IGNEO

The Igneous rocks, including under this name the *plutonic* or older igneous, and *volcanic* or more modern rocks, are extensively distributed over the earth's surface. T form the solid frame-work of the globe, and appear to have once existed in a state of igne fusion, from which they have cooled down. They contain no trace of organic life; many valuable minerals and metallic ores, as tin, lead, silver, copper, &c., are founc them. The igneous rocks are either amorphous or at times exhibit a jointed structu being separable into cubical or prismatic masses. They are generally crystalline, consist mostly of a mixture of more or less crystalline minerals.

Granite consists of quartz, felspar, and sometimes mica or hornblende; when ho blende is substituted for mica, the rock is termed Syenite. Granite is of various colou mostly dependent on the character of the contained felspar or mica. It sometimes prese a cuboidal or rude columnar structure. Granite, although generally considered a prim rock, and the foundation upon which the stratified rocks are placed, appears to be of geological ages, both secondary and tertiary; the latter strata in the Andes having b observed by Mr. Darwin to be traversed by this rock. Protogine is a variety of gran containing the mineral talc; and Pegmatite is another form of granite, in which the fels and quartz are regularly arranged, whence it is sometimes called graphic granite.

Serpentine or Ophiolite, principally consists of silicate of magnesia, combined with li water, and oxide of iron. Diallage is nearly allied to Serpentine.

Greenstone (Diorite, &c.) consists of hornblende and compact felspar. Hypersthene Augite Greenstone contains an admixture of either hypersthene or augite.

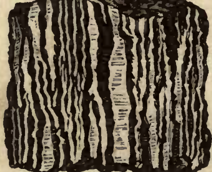
In **Porphyry**, crystals of quartz or felspar are imbedded in a granitic or homogenous ba

Amygdaloid (Almond-stone) contains almond shaped cavities, either empty, encrust half, or completely filled. [Trachy

Trachyte is a felspathic rock. Pitchstone, pumice, and greystone are varieties

In **Basalt**, augite predominates over felspar. Where basalt, and indeed also ot igneous rocks exhibit a resemblance to a series of steps, they have received the name *trap rock*. Under the general name of trap rock are included all basalts and other rocks volcanic origin. Fingal's Cave, presents a beautiful example of columnar basalt.

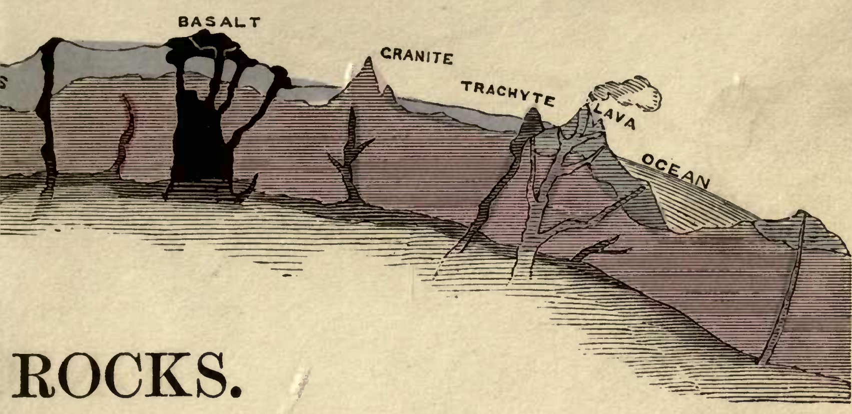
Lava is the result of modern volcanic action; it is very variable in its composition a structure, being allied to the basalt and trachytes.



GRAPHIC GRANITE.

FINGAL'S CAVE, Isle of Staffa.

LONDON: PUBLISHED



ROCKS.

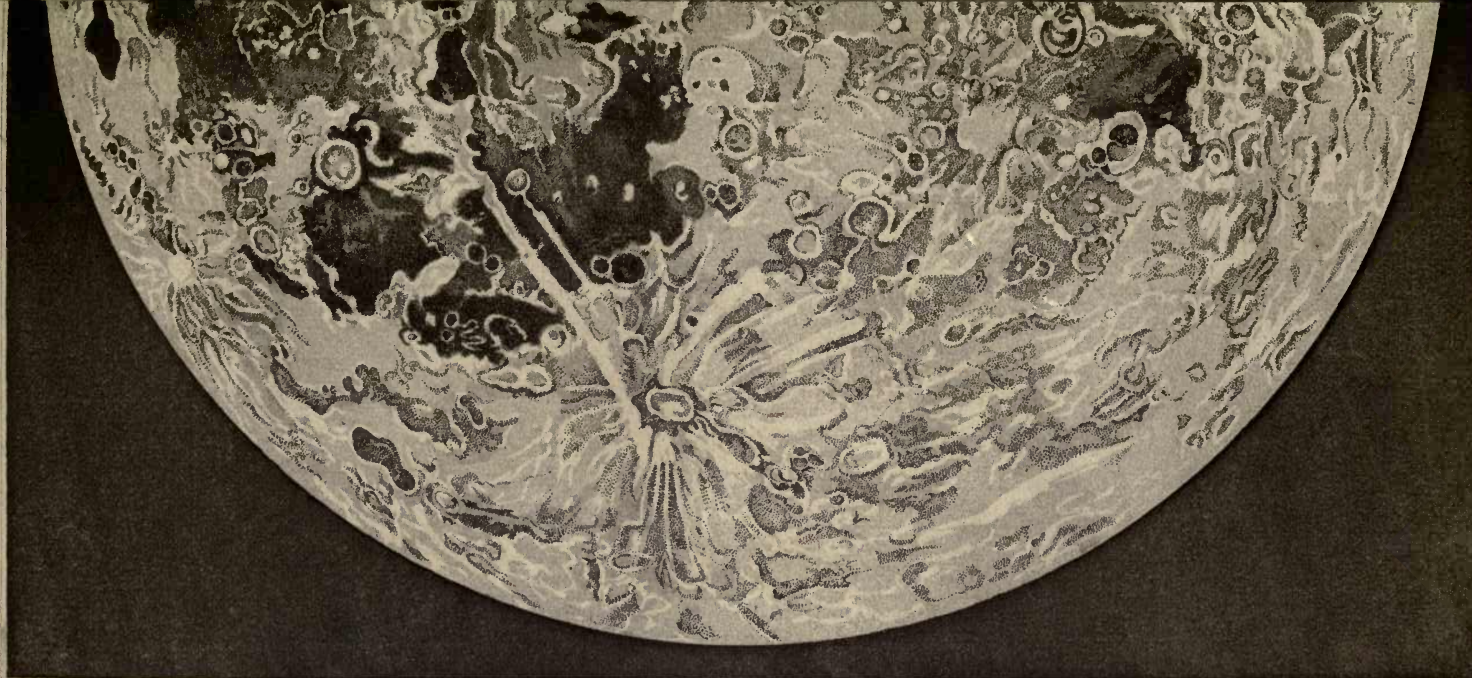
ranite Veins. In some parts of Britain, and also in other countries, granite veins
: been observed proceeding from the mass of granite rock beneath, and traversing in all
ctions the superior and overlying strata. In Glen Tilt, and at Cape Wrath, Scotland,
gneiss and mica-schist are intersected with numerous granitic veins, the intrusion of
ch must have been therefore of later date than the rocks they traverse.
ne Igneous Rocks generally form the crests or elevated peaks of mountain summits;
if not always entirely composing the upper limit, have by their action and elevating
: on other strata, given an elevation and direction to many of the principal mountain
ns, thereby producing one of the chief physical features of the earth's surface. It is to
effects arising from the action of igneous rocks, or to their peculiar structural cha-
er, that the picturesque features of much mountain scenery is due, as well shown in
bold and rugged outline of the naked and abrupt rocks, and the gradually tapering
s, called Aiguilles, in the Alps. The Caucasus and Himalayas present examples of the
ations of ancient disruption or subsequent weathering of the rocky mass. To this
r agency may be attributed the singular forms of some of the granite of Cornwall.
ne principal elevations of Devon and Cornwall, as the Brent Tor, Dartmoor, Exmoor,
are composed of grey coloured, coarse, and sometimes very porphyritic granite, in
h large crystals of felspar are imbedded. Specimens of this may be seen in the pave-
; of London Bridge. Granite is also found in Cumberland and Westmoreland, and in
esea. It also occurs in Scotland, and is extensively quarried near Aberdeen.
Syenitic Granite forms the chief part of the Malvern Hills, and a similar rock occurs
Barrow-on-soar, Leicestershire, where it is extensively quarried as a road stone.
ite forms the principal chains of Norway, Sweden, and Finland, portions of the Alps,
nees, and mountain chains of Bohemia, also of the Ural, Altai, and Himalaya ranges,
t occurs over extensive tracks in Africa, and South America.
anite and the allied rocks are extensively used in the arts and manufactures; some of
olossal figures in the Egyptian saloon of the British Museum, afford examples of the
yenitic granite, basalt, and other igneous rocks. The granitic rocks are a source of
ner useful material for the manufacturer, the china clay is derived from the decompo-
of the felspar, one of the materials of granite, thus producing a substance from which
ner varieties of china and porcelain are manufactured.

AIGUILLE DE DRU, Alps.

PORPHYRITIC GRANITE.

YNOLDS, 174, STRAND.

TELESCOPIC APPEARANCE OF THE MOON.

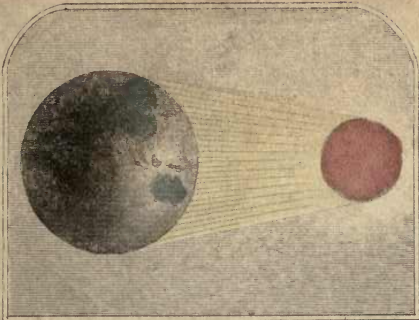


Drawn & Engraved by John Emslie

The appearance of the Moon as seen by Lord Rosse's great telescope is thus described by Dr. Scoresby. "It appeared like a Globe of Molten Silver, and every object of the extent of a hundred yards was quite visible. Edifices, therefore of the size of York Minster might be easily perceived if they had existed. But there was no appearance of anything of that nature; neither was there any indication of the existence of water or of an atmosphere. There was a vast number of extinct volcanoes, several miles in breadth; through one of them there was a line in continuance of one, about 160 miles in length which ran in a straight direction like a railway. The general appearance however, was like one vast ruin of nature."

Published by James Reynolds, 174 Strand, London.

PHENOMENA OF DAY AND NIGHT

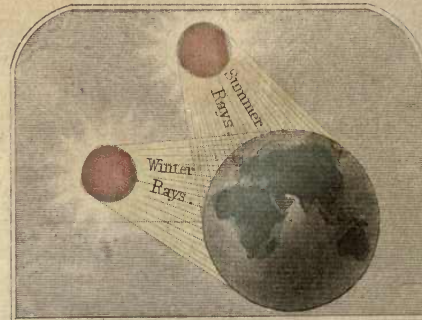


Caused by the diurnal rotation of the Earth upon its Axis.

THE SUN AND SOLAR PHENOMENA.

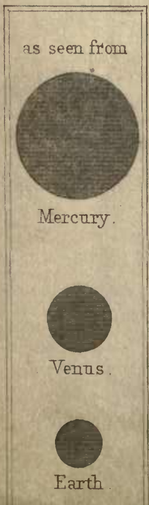
Modern Astronomers are of opinion that the Sun is an opaque body surrounded by luminous matter, and that the spots observed are openings in this luminous covering, showing the body of the Sun. The spots are of various sizes, some being more than 40,000 miles in diameter.

SUMMER AND WINTER RAYS.

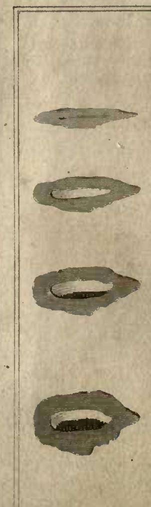


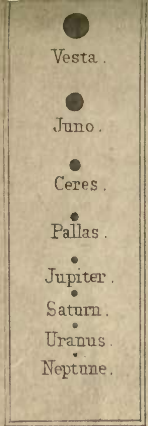
The Sun attains a greater altitude in Summer than in Winter.

COMPARATIVE SIZE OF THE SUN

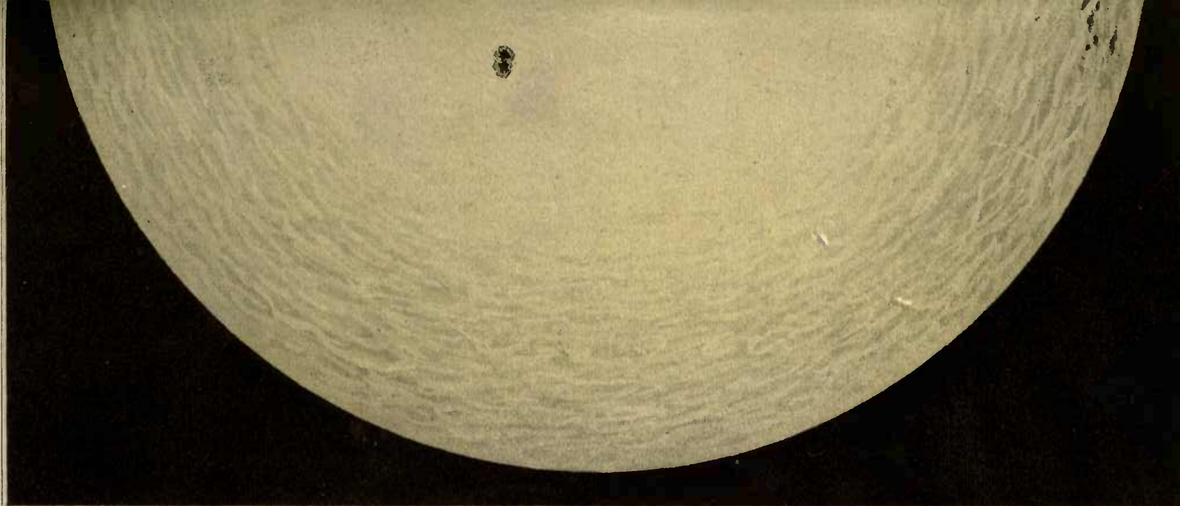


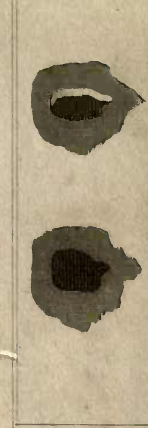
APPEARANCE OF A SPOT UPON THE SUN





AS SEEN FROM THE VARIOUS PLANETS,





AS SEEN PASSING OFF ITS DISC.

TRANSIT OF MERCURY.

A Transit occurs when Mercury is between the Earth and the Sun in a straight line joining the centres of the two bodies. It is a somewhat rare phenomenon.

THE SUN AT MIDNIGHT AT THE NORTH CAPE OF EUROPE.

Drawn & Engraved by John Emslie

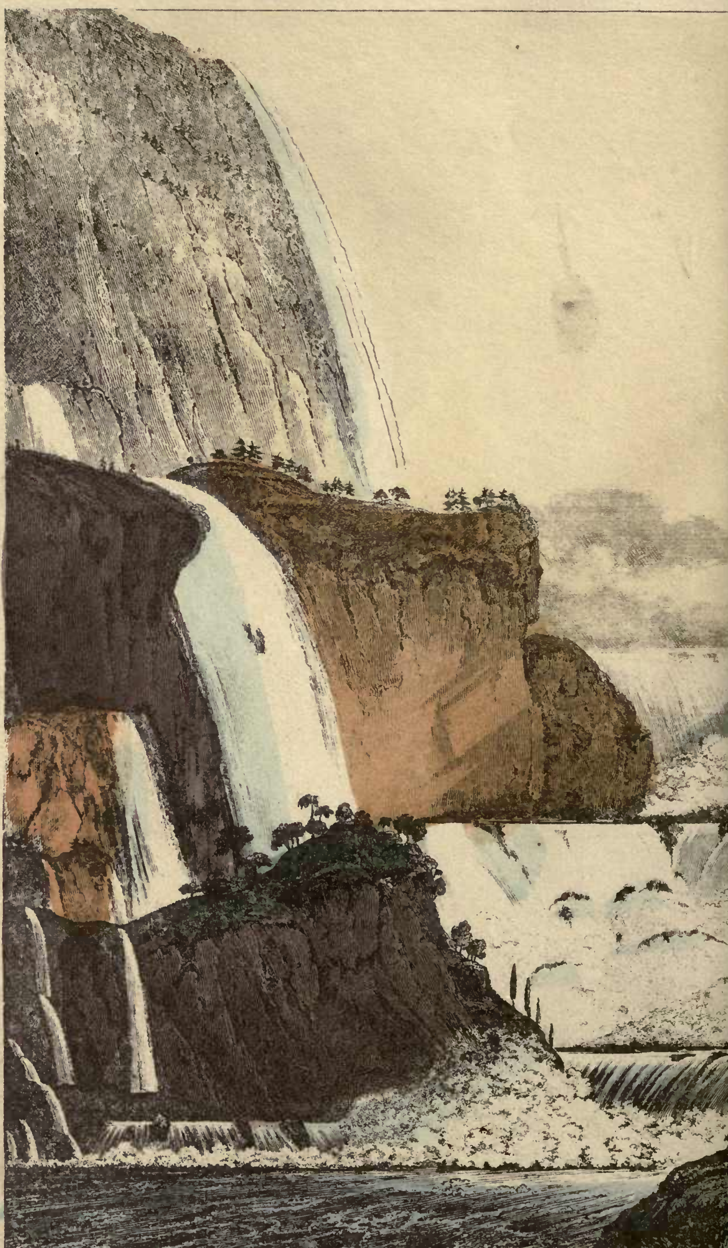
London Published by J. Reynolds, 174 Strand.

ANNULAR ECLIPSE.

Caused by the Moon, when directly between the Earth and the Sun, passing across the centre of the Sun's disc which then presents the annular form.

WATE

	Feet
Gavarny, *Pyrenees*.	1260.
Lauterbrunn, *Switz.d*	900.
Rioucan, *Norway*.	800.
Tequendama, *Columbia*.	539.
Missouri, *N. America*.	400.
Grey Mare's tail, *Scotland*	350.
Hepste,	300.
Terni, *Italy*.	270.
Foyers, *Scotland*.	207.
Cettina Fall, *Dalmatia*.	150.
Tendon, *France*.	125.
Genesse, *New York*	100.
Rhine, *Lauffen, Switz.d*	65.
Tivoli, *Italy*.	50.
Maupas, *France*.	45.



Drawn

Waterfalls *have ever been regarded among the most interesting and beautiful of the w*
rain falls or snow melts. This is particularly the case in the northern parts of the A
slope in the bed of a river, as causes the water to rush down in that particular part wi
suddenly by a steep descent, as a ledge or mass of rock: over this edge the water is pre
occur in a more gentle form they are called **Cascades**.

London. J. Reynolds, 174. Strand

FALLS.

Feet

900. Staubbach, *Switz*

800. Seculejo, *Pyrene*

600. Lulea, *Swed*

500. Serio dell Adda *Ita*
469. Tosa, *Piedmo*

380. Powerscourt, *Irelan*

300. Nakchikin, *Kamstshatk*

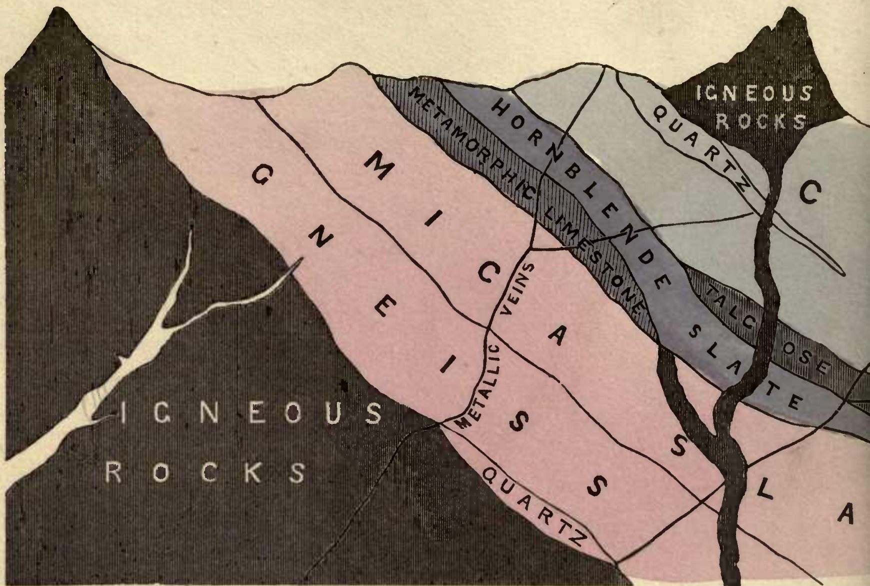
242. Montmorency, *Cana*

160. Wilberforce, *N. Americ*

145. Niagara, *Cana*
120. Rupin, *Himala*
115. Kakabika, *S. Ameri*
100. Lidford, *Englan*
80. Oyapock, *French Guia*
60. Trolhetta, *Swede*
52. Parana, *Paragu*
10. Cataracts of the Nile, *Egy*

ture. They are most numerous among wild and rocky mountains upon which much
ntinent where rapids and other waterfalls abound. Rapids *are occasioned by such a*
rce and swiftnefs. Cataracts *occur when the level on which the water runs terminates*
almost perpendicularly, with amazing impetuosity and grandeur. When these falls

s. Rocks & C°. Peacock & Mansfield.



METAMOR

The **Metamorphic Rocks** generally lie over or against the igneous rocks, and exhibit mos a schistose and stratified character, combined frequently with a highly crystalline structu They are supposed to bear marks of an aqueous origin, subsequently influenced by the act of heat. Another theory supposes them to be broken fragments of igneous rocks, re-arrang into layers or beds by the action of water.

The Metamorphic Rocks are destitute of organic remains. Veins of copper and lead have been found in these rocks, as also those of iron, silver, gold, tin, &c.

The Metamorphic Rocks are widely distributed, and form a great part of the earth's cru they are found in Scandinavia, Northern Russia, Ireland, the Highlands of Scotland, the Al in Brazil, India, Africa, and North America. The scenery of the districts composed of th rocks is frequently wild and picturesque, and the surface often sterile and unproductive, par arising from the nature, but generally from the elevation they attain.

Gneiss consists of quartz, felspar, mica, and sometimes hornblende, arranged in disti layers; with the latter mineral it may be termed syenitic gneiss.

Mica Slate is a foliated aggregate of mica and quartz, and sometimes contains crystals garnet and hornblende.

In **Hornblende Slate,** hornblende forms the greater part of the composition. It consi of a mixture of hornblende and felspar or quartz, and is called *Metamorphic-greenstone* or *gre stone slate.* The metamorphic limestone of the primary period, is often white and crystalli and furnishes some fine marbles, and contains occasionally veins of chlorite, steatite, and so disseminated minerals, as augite, &c.

Chlorite Slate consists chiefly of chlorite, sometimes with quartz, felspar, hornblende or mi

Metamorphic Sandstone, or **Quartz Rock** is granular, and occasionally occurs as vei in the other rocks.

Clay Slate is a slaty rock of extremely fine ingredients, containing the elements of t other rocks in a very comminated state, subsequently altered.

Talcose Slate is a soft, unctuous, and fissile rock, containing talc as an ingredient, generally associated with quartz.

Actynolite Slate or **Schist** is slaty rock, formed chiefly of actynolite, with some felspar, quartz or mica.

Serpentine, although classed with the igneous rocks, may also be considered as belonging to this series.

The Metamorphic Rocks in the above list may be divided into two

SL.

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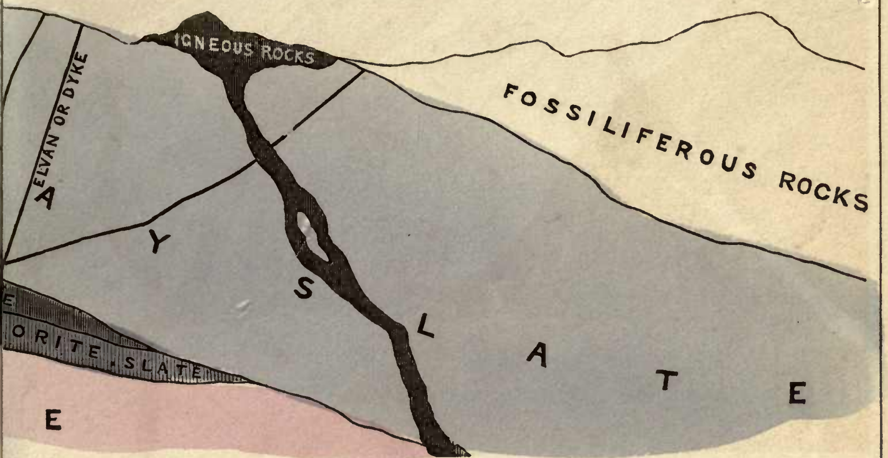
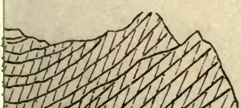


IC ROCKS.

ries, those which are rudely stratified, laminated, foliated or slaty, as gneiss, mica slate, clay slate; nd those which are unstratified, as quartz rock, and the perfectly crystalline limestones or marbles Metamorphism, or the changes the various strata have undergone, may have arisen from the fects of heat, heated vapours, gaseous exhalations, or the proximity of igneous rocks; and nese changes may have been different, according to the localities. Thus, in some places, nere may be simply a re-arrangement, or alteration of the mineral substance, as the conver-on of an earthy into a crystalline substance; others may have undergone an entire change, r even loss of a portion of their substance; a third change may have effected the introduction r elimination of minerals in some localities, which are not generally found in others; and a ourth change may entirely alter, or even obliterate the original character, and produce a new ructure in the rock, as in slaty cleavage.

Although many of the Metamorphic Rocks are merely the altered palæozoic strata, and con-equently referred to the primary series, still there are others of a considerable later date. 'or as igneous action has been in operation during every period of the earth's history, so it is robable that different strata have been successively changed. Thus, some of the limestones r finer marbles of the south of Europe, as that of Carrara and other localities, which were ormerly considered to belong to the primary series, are now ascertained to be of the age of ne jurassic rocks. The calcareous and argillaceous strata belonging to the lias, in the western lands of Scotland, (Portree, for example) have been converted into highly compact limestones nd a species of lydian stone. The basaltic rocks and dykes which form so prominent a feature n the north coast of Ireland, have effected a change in the earthy chalk of that vicinity, (as the Island of Raghlin), with which they are in contact, converting it into compact, and ometimes granular limestone.

The ordinary roofing slates belonging to the clay-slate group, are the result of metamorphic ction. These argillaceous strata were originally deposited as fine sediment at the bottom f the sea, and have been subsequently elevated from their original position, consolidated and contorted; and have been also subjected to the operation of other forces, which have produced a peculiar structure or slaty cleavage, which cleavage is very uniform over large areas, and generally obliterates the original planes of stratification, and rarely coincides with them. In the accompanying figure, the undulating lines are the planes of bedding, and the oblique lines are those of slaty cleavage.



AGE.

EYNOLDS, 174, STRAND.

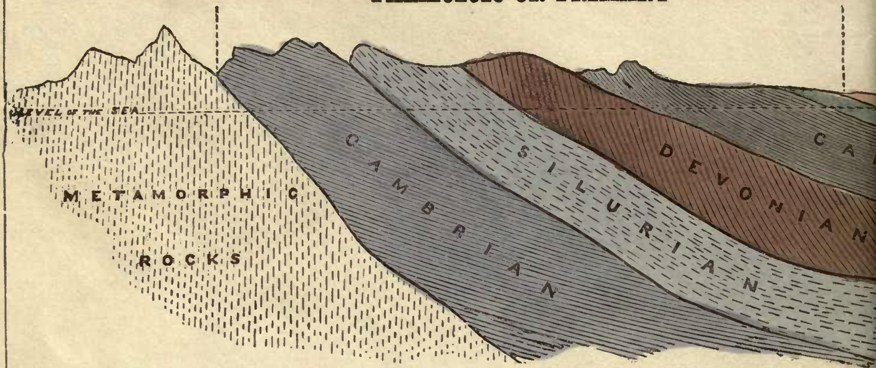
[illegible]C ROCKS.

[illegible] those which are either crystalline, laminated, banded, or slaty, as gneiss, mica slate, clay slate, [illegible] those which are quartz rock, and the peculiar crystalline limestone or marble [illegible] differing from the changes the various strata have undergone, may have arisen from the [illegible] heat, heated vapours, gaseous exhalations, or the proximity of igneous rocks; and [illegible] changes may have been different, according to the localities. Thus, in some places, [illegible] may be simply a re-arrangement, or alteration of the mineral substance of the original [illegible] into a crystalline substance; others may have undergone an entire change, [illegible] a portion of their substance; a third change may have effected the introduction [illegible] of minerals in some localities, which are not generally found in others; and a [illegible] may entirely alter, or else obliterate the original character, and produce a new [illegible], as in slaty cleavage.

[illegible] many of the Metamorphic Rocks are merely the altered sedimentary strata, and [illegible] referred to the primary series, still there are strata of a considerably later date [illegible] metamorphic action has been its operation during every period of the earth's history, [illegible] different strata have been successively changed. Thus, some of the limestones [illegible] of the north of Europe, as that of Carrara and other localities, which were [illegible] considered to belong to the primary series, are now ascertained to be of the more [illegible] periods. The sandstones and argillaceous strata belonging to the [illegible] [illegible] Scotland, (Ulster, for example) have been converted into highly compact [illegible] [illegible] of Jurassic rocks. The basaltic and igneous dykes which have [illegible] of a [illegible] [illegible] Ireland, have effected a change in the earthy [illegible] [illegible] [illegible] which they are in contact, converting [illegible] into [illegible] and [illegible] porcelain [illegible].

[illegible] slates belonging to the clay-slate group, are the [illegible] [illegible]. These argillaceous strata were [illegible] deposited as fine mud, [illegible] the bottom [illegible] and have been subsequently hardened, [illegible] their original position [illegible] and [illegible] [illegible] and have [illegible] been subjected to the operation of other [illegible], which have produced a peculiar structure or slaty cleavage, [illegible] cleavage is very uniform over large areas, and generally [illegible] the original planes of stratification, and [illegible] [illegible] [illegible]. In the accompanying figure, the [illegible] lines [illegible] the planes of bedding, and the oblique lines are those of slaty cleavage.

PALÆOZOIC OR PRIMARY.



FOSSILIFEROUS OR

The various strata composing the stratified or fossiliferous rocks, although frequent presenting the same mineral character, have a definite and constant order and arrangeme which is never inverted. Thus, a group of strata in England, characterized by a certain set fossil remains and *overlying* another group containing a different set of fossils, are never fou in other countries to *underlie* the latter; the position of strata in relation to each other a therefore uniform and invariable, and upon this uniformity depends the practical and econ mical bearings of Geology.

The sedimentary rocks are those which include the remains of animals and vegetables, m or less abundantly, and are hence termed the fossiliferous rocks. They are generally eitl arenaceous, argillaceous or calcareous deposits, which owe their origin to the agency of wat being formed within the bed of the sea, or at the bottom of freshwater streams or lakes, indicated by the nature of the contained remains; with which also are sometimes associa land plants, showing that a terrestrial surface existed at different periods, and from t destruction of a portion of which, the sandy and clayey beds were probably derived.

The stratified rocks are for convenience divided into three great series, according to th relative antiquity, and the fossil remains found in them, which materially differ and are read distinguished from each other; and they present three great life periods, to which the ter primary, or palæozoic; secondary, or mesozoic; and tertiary, or cainozoic, have been applie

PALÆOZOIC, OR PRIMARY SERIES.

The primary series, overlyiug the metamorphic rocks, constitute with them some of most elevated and picturesque scenery of the British Isles, as in Cornwall, North and So Wales, the district of the Lakes, Scotland, and a large part of Ireland. From the frequ association of igneous rocks with some of them, they have undergone considerable change a induration, and are in this respect allied to the metamorphic rocks—in fact, the ordin roofing slates so extensively quarried near Bangor, and previously alluded to, form a mem of this series. Like the metamorphic rocks also, they contain many valuable deposits mineral wealth. Fine marbles are obtained from this series; and the durable magnesian Li stone used in constructing the Houses of Parliament, belongs to the permian group. Besi the valuable substance, coal, the carboniferous group contains rich deposits of iron ore and l

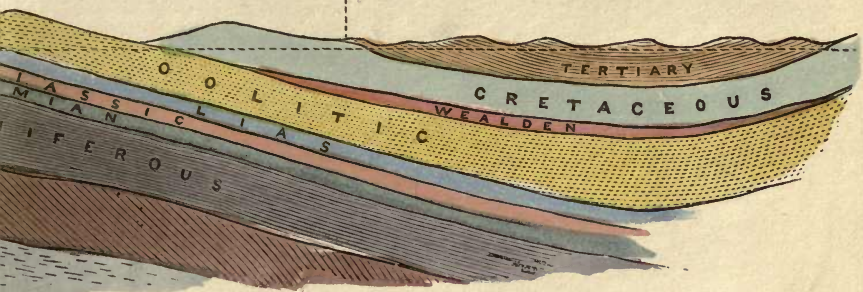
The Cambrian Rocks include a considerable thickness of schists, sandstones, and c glomerates, as the Harlech grits, and the Llanberis and Longmynd strata. They are nea unfossiliferous, only a faint trace of organic remains having been detected in them in Irela Some geologists include an upper and more fossiliferous series, as the Lingula and Trema beds of North Wales, which are considered by others to form the lower zone of the next gr

The Lower Silurian group, including the upper beds just mentioned, and the Cara sandstones and Llandeilo flags of Wales, constitute a series containing many fossils. T have been traced in Wales, Cumberland, Scotland, Ireland, France, Spain, Germany, Russia,

The Upper Silurian group were first described by Sir R. Murchison, and include the stones, Ludlow group, and Wenlock and Woolhope strata, and are marked by a gre develo pmentof limestone, containing a large series of fossils.

The Devonian, or Old Red Sandstone, presents two aspects, one that of Scotland and border counties of Wales, consisting of coarse conglomerates, sandstones, and impure li stones, locally called cornstones, and containiug many peculiar fishes; the other, tha

OZOIC OR SECONDARY. CAINOZOIC OR TERTIARY.



DIMENTARY ROCKS.

vonshire, with a greater development of limestones, (ornamental marbles, &c.) and conning many species of corals, shells, and some trilobites.

The **Carboniferous** group, so called from being the depository of the important substance, l. A limestone shale usually interposes between the carboniferous limestone and the old l sandstone. Next above is a deposit of hard, coarse sandstone, called millstone grit; and ove this occurs an important series of sands and shales, called coal measures, and which terstratified with them,) contain the valuable mineral, coal. They are widely distributed in e British Isles, Belgium, Germany, France, Spain, America, Asia, &c.

The **Permian** group, or upper member of the primary series, includes sandstones, marl te, gypseous beds, and magnesian limestones, some of the latter are durable building stones. Germany, this group contains a thin band of copper slate, from which copper is obtained.

MESOZOIC, OR SECONDARY SERIES.

The secondary series comprise a set of alternating strata of sand, clay, and earthy limenes, generally less indurated than those of the primary series. In an economical point of w, they are not less important; the rich deposits of rock-salt and beds of gypsum, as well some good sandstones, belong to the triassic or lower portion of this series. From some of e lias clays alum is made, and jet is obtained; the finer oolitic limestones are extensively rked near Cheltenham, Bath, and in the Isle of Portland; the Purbeck and Wealden strata eld some marbles which were largely used in many of the earlier churches and other edifices. e cretaceous group is valuable for the lime, beds of flint, firestone, fuller's earth, &c.; while me portions of the lower chalk yield abundance of phosphatic nodules, useful in agriculture.

The **Lower Secondary or Triassic** group, includes the variegated sandstone, muschellk, (wanting in England,) and the upper new red sandstone or variegated marl. The latter ntains gypsum (plaster of Paris) and large deposits of rock salt.

The **Middle Secondary** comprises the liassic group; the oolitic or jurassic group, which sub-divided into three parts; and the purbeck and wealden groups.

The **Upper Secondary or Cretaceous** group, includes the lower green-sand, gault, upper een-sand, and the chalk strata.

CAINOZOIC, OR TERTIARY SERIES.

The tertiary series are not so economically important. Cement stones are obtained from e London clay, which is also used for the manufacture of tiles; bricks are chiefly made from e clay and loam beds of the upper part of this series, and which generally occur along the esent river courses, and frequently contain remains of extinct mammalia, associated with ing fresh-water and land shells. Some portions of the crag deposits in Suffolk are extenvely worked for argillaceous nodules, highly impregnated with phosphatic matter, and which ter undergoing a certain process, form a highly valuable manure.

The **Lower Tertiary or Eocene**, includes the Thanet sand, Woolwich beds, and the ondon clay, the beds of the Paris basin, and also of Belgium, the Bracklesham and Barton rata of Sussex and Hampshire, and the fluvio-marine beds of the Isle of Wight.

The **Middle Tertiary or Miocene**, includes the upper molasse of Switzerland, the brown al deposits of Germany, &c., the faluns of Touraine, the beds near Bordeaux, &c. in France.

The **Upper Tertiary or Pliocene**, comprises the coralline or red crag, sub-appenine beds, ift, also the alluvial and diluvial deposits, the fresh-water beds, and the gravel deposits.

TABLE OF GEO

SE

ORDER OF SUPERPOSITION AND MINERAL CH

WITH THEIR MEAN THICKNESS, AND SOME

	GROUPS.	STRATA.	MINERAL
Cainozoic or Tertiary Series.	Pleistocene.	Modern Deposits	River Deltas, Raised Beaches, Peat Bo
	N. Pliocene.	Mammaliferous or Norwich Crag.	A ferruginous shelly Sand, with beds o
	O. Pliocene.	Red Crag	Beds of ferruginous Sand and Gravel,
	”	Coralline Crag	White calcareous Sand, with Shells an
	Miocene.	(Wanting in England)...............	The leaf beds of the Isle of Mull proba
	Eocene.	Fluvio-Marine Beds..................	A series of strata of Sands, calcareous
	”	Barton Clays..........................	Yellow and white Sand, dark Clay wit
	”	Bagshot and Bracklesham Sands..	Yellow ferruginous Sands, and Sandst
	”	London Clay and Bognor Beds ...	Dark blue or brown Clay, and beds of
	”	Plastic and Mottled Clays	Clays of variegated colours, as red, gr
Mesozoic or Secondary Series.	Cretaceous.	Upper Chalk	Soft Chalk (an earthy carbonate of Li
	”	Lower Chalk	Chalk of a harder nature, and of a less
	”	Chalk Marl	Grey Chalk, soft and very argillaceous
	”	Upper Greensand	A silicious or calcareous Sand, with gr
	”	Gault	Blue marly Clay, sometimes tenacious
	”	Lower Greensand	A mass of green or ferruginous Sands,
	Wealden.	Weald Clay	Strong Clay of a blue or brown colour,
	”	Hastings Sands........................	White, yellowish and ferruginous Sand
	Purbeck.	Purbeck Beds	Sandstones, argillaceous Shales, and b
	Upper Oolite.	Portland Rock and Sands	Limestone, oolitic and shelly, coarse, f
	”	Kimmeridge Clay.....................	Dark blue or black slaty Clay, with bi
	Middle Oolite.	Upper Calcareous Grit	Sands, with beds and nodules of calcar
	”	Coralline Oolite......................	Coarse, shelly, rubbly, and oolitic Lim
	”	Lower Calcareous Grit	Sands, with beds and nodules of calca
	”	Oxford Clay	Dark blue Clay, sometimes slaty and b
	”	Kelloway Rock	A bed of ferruginous, coarse, sandy Li
	Lower Oolite.	Cornbrash	Coarse, shelly, rubbly Limestone, thin
	”	Forest Marble	Coarse, shelly, oolitic Limestone, Sand
	”	Bradford Clay	A greyish tenaceous Clay, sometimes
	”	Great Oolite	Oolitic Limestone and Freestone, uppe
	”	Stonesfield Slate	Oolitic, silicious Limestone, very fissile
	”	Fullers' Earth	Marls and Clays, containing the argill
	”	Inferior Oolite	Coarse, shelly, calcareous Ragstone, w
	Lias.	Upper Lias Shale	Dark blue coloured Clay, laminated al
	”	Marlstone	Calcareous, sandy, and ferruginous be
	”	Middle Lias Shale....................	Dark inter-laminations of Clays and S
	”	Lias Limestone........................	A series of laminated argillaceous blue
	”	Lower Lias Marls.....................	A series of beds of dark purple slaty M
	Triassic.	Variegated Marls or Keuper	Variegated greenish, blue, and white M
	”	Muschelkalk, *wanting in England*	(Marls, enclosing laminated Sandstone
	”	Red Sandstone or Bunter	Red and white Sandstone, mostly fine
Palæozoic or Primary Series.	Permian.	Knottingley Limestone	Grey laminated Limestone, slightly m
	”	Gypseous Marls	Red, blueish and white Clays and Mar
	”	Magnesian Limestone	Fawn-coloured, granular, and compact
	”	Marl Slate	Laminated, impure calcareous beds of
	”	Lower Red Sandstone	Red, grey, or yellow silicious grit, som
	Carboniferous.	Coal Measures	Beds of Coal, alternating with layers o
	”	Millstone Grit	Pebbly, coarse and fine quartzose Grit
	”	Mountain Limestone	Compact or crystalline Limestone, thi
	”	Limestone Shales	Argillaceous Shales, dark-coloured an
	Devonian.	Quartzose Conglomerates	Quartzose grits and conglomerates, pa
	”	Cornstone and Marl..................	Coloured Marls, with alternating band
	”	Tilestone Series.......................	Finely laminated, hard micaceous quart
	Upper Silurian.	Ludlow Rocks	Grey micaceous laminated Sandstones,
	”	Wenlock Rocks........................	Grey nodules, stratified Limestone and
	Lower Silurian.	Caradoc Rocks	Thin Sandstones and Shales, Limeston
	”	Llandeilo or Bala Rocks	Beds of dark coloured flags, mostly cal
	Cambrian.	Snowdon, Skiddaw, Bangor, and Longmynd Rocks	A series of grits, slates, conglomerates,

Note.—The average th

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GICAL STRATA,

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CTERS OF THE VARIOUS STRATIFIED ROCKS;

HE LOCALITIES WHERE THEY ARE FOUND.

TERS, THICKNESS, AND LOCALITIES WHERE FOUND.

rged Forests. [Cavern Deposits, Mammalian beds, and the Boulder or Drift Clay.
ed Clay and Loam. 4 to 12 feet. *Thorp near Norwich; Bridlington, Yorkshire.*
Shells, and locally layers of Phosphatic Nodules. 30 feet. *Near Ipswich, Sutton, Ramsholt.*
rals, sometimes compact, forming thin beds of Limestone. 20 feet. *Orford, Ramsholt.*
to this epoch? (The shell beds of Touraine and Bordeaux in France.)
laceous Marls, Limestones, greenish Marls, &c. 400 feet. *Headon Hill, Binstead, Shalcombe.*
grains, septaria and iron Sand. 250 feet. *Barton Cliffs, Hampshire.*
layers of flint Pebbles, and coloured Clays and Sands. 540 feet. *Bagshot Heath, Bracklesham.*
een, and other coloured Sands, nodules of Septaria. 520 feet. *London, Isle of Sheppey, Bognor.*
, &c., and layers of coloured Sands and Pebbles. 100 ft. *Reading, Blackheath, Woolwich, Alum Bay.*
beds and nodules of Flints. 300 feet. *Northfleet, Purfleet, Brighton, Danes Dyke, Yorkshire.*
our, with few or no Flints. 350 feet. *Near Cambridge, Flamborough Head, Dover Cliffs.*
t. *Dover; Wiltshire; near Cambridge; Surrey and Sussex.*
, sometimes compact, and with layers and nodules of Chert. 120 feet. *Merstham, Isle of Wight, &c.*
times soft, with green grains disseminated in it. 50 to 100 feet. *Folkstone, Cambridge.*
rs of Chert and local beds of Limestone and Fullers' Earth. 250 feet. *Near Maidstone; Hythe, &c.*
beds of shelly Limestone called Petworth Marble, and Ironstone. 150 feet. *Weald of Sussex, &c*
able Sandstones. Tilgate Stone, a compact grey grit. 500 feet. *Hastings, Tunbridge Wells, &c.*
hwater Limestones and Marbles. 150 feet. *Swanage Bay, Warbarrow Bay, &c. Dorsetshire.*
l or compact, with layers of Chert, and subordinate beds of Sand. 150 feet. *Isle of Portland.*
Shale, Selenite and Septaria. 400 feet. *Kimmeridge and Encombe Bays, Dorsetshire.*
stone. 20 to 60 feet. *Scarborough, Yorkshire; near Oxford.*
some places entirely composed of Coral. 30 feet. *Farringdon, Calne, Malton, Pickering, Scarboro.*
stones. 20 to 50 feet. *Scarborough, Malton, Yorkshire, and Wiltshire.*
, containing Septaria and Selenite. 400 feet. *Oxford, Chippenham, Scarborough, Weymouth.*
very variable in quality and colour. 30 feet. *Kelloway Bridge, near Chippenham, Scarborough, &c.*
ith layers of Clay and calcareous Sandstone. 10 feet. *Malmsbury, Chippenham, Yorkshire, &c.*
retions of fissile Limestone, and layers of blue Clay. 30 feet. *Corsham, Cirencester, &c.*
with thin beds of brown Limestone. 10 to 20 feet. *Bradford, Wilts; Tetbury, Cirencester, &c.*
y shelly, the rest sometimes sandy, and often thick bedded. 120 feet. *Bradford Hill, near Bath, &c.*
Stonesfield, Oxfordshire; Sevenhampton Common, Gloucestershire.
bstance called Fullers' Earth. 30 to 100 feet. *Old-down Hill, near Bath; Box; near Stroud.*
f ferruginous Sand, with concretions of sandy Limestones and Shells. 250 feet. *Cotteswold Hills.*
, sandy Limestone and Shale. 50 to 200 feet. *Whitby; Barrow-on-soar, Leicestershire; Lyme Regis.*
s of Ironstone. 30 to 150 feet. *Staithes, Yorkshire; Dumbleton Hill, near Cheltenham, &c.*
layers of nodules of argillaceous Limestone. } 60 to 400 ft. { *Dumbleton; Battledown, nr. Cheltenham.*
Limestone, with partings of Clay or Shale. } 60 to 400 ft. { *Barrow-on-soar, Lyme Regis.*
grey Limestone, and the bone bed of Bristol. } 60 to 400 ft. { *Lyme Regis, Bath, Bristol.*
dstone and Shales, with veins of Gypsum and Rock Salt. *Warwickshire, Cheshire, Derbyshire.*
aterstone, form a middle group in Cheshire. 400 feet.)
nd often impregnated with Salt. Red Conglomerate. 600 feet. *Cheshire, Lancashire, &c.*
fine grained and thin bedded. 40 feet. *Knottingley and Doncaster, Yorkshire.*
ypsum. 50 feet. *Mansfield, Nottinghamshire; Manchester*
n Limestone, thick bedded. 300 feet. *Derbyshire, Yorkshire, Ferry Hill, &c.*
gillaceous or sandy nature. 60 feet. *Durham.*
nglomeritic, loose Sands, variegated Marls, grey micaceous Sandstone, &c. *Shropshire, &c.*
micaceous Sandstone, Ironstone, and occasionally Limestone. 3000 feet. *Northern Counties, &c.*
hales, Ironstones, thin Limestones, and sometimes beds of Coal. 600 feet. *Northumberland, &c.*
l. In some parts beds of Marble, veins of Lead and Calamine. 2400 feet. *Derbyshire; Bristol.*
sometimes bituminous. 1000 feet. *Lanarkshire, Linlithgowshire, &c.*
nwards into a dark reddish-brown coarse grained Sandstone. *Symonds Yat, Monmouthshire.* } 5000 to 8000 ft.
stone, and concretionary impure Limestone. *Near Hay and Abergavenny.* } 5000 to 8000 ft.
lstones, and beds of reddish Shale. *Between Ludlow and Downton Castle; Caithness, &c.* } 5000 to 8000 ft.
ales, and grey argillaceous and somewhat crystalline Limestone. 2000 feet. *Ludlow, &c.*
nd dark argillaceous Shale, with nodules of earthy Limestone. 1800 feet. *Wenlock, Dudley, &c.*
zose grits, conglomerates and Freestones. 2400 feet. *May Hill, Gloucestershire; Coniston, &c.*
with conglomerates, Sandstone Shale, and Schist. 1200 feet. *Builth, Bala, &c.*
rstratified trappean rock. 20,000 feet. *Snowdon, Cader Idris; Cumberland, &c.*
given in round numbers, subject however to considerable variation in different localities.

REYNOLDS. 174, STRAND.

THE CARBONI[illegible]

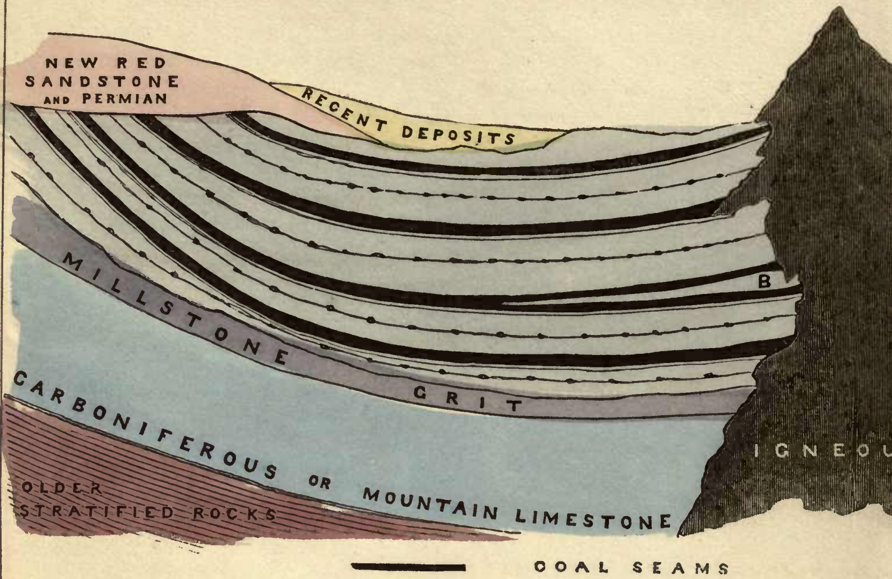
The Carboniferous is the most important group connected with the industrial economy of this and other countries. Independently of its supplying the valuable fuel coal, [illegible] series of strata it contains other useful substances. It is in this country the most [illegible] the iron ores; it also yields fire-clay, millstones, marbles, and limestones, the latter enclosing rich deposits of lead ores. The group is commonly divided into Mountain Limestone, Millstone Grit, and Coal Measures, but these are subject to local variation.

The Carboniferous or Mountain Limestone, may generally be regarded as the base of the whole Carboniferous group. In the north of England and Scotland, however, this limestone is not a uniform bed underlying the coal measures. In Ireland and other parts of Europe the limestone is separated from the Devonian rocks by shales and sandstones. The [illegible] [illegible] of the limestone of this period varies from a few feet to [illegible] feet; the rock is usually hard, and contains in its fissures numerous crystalline minerals, and ores of lead, zinc, and other metals.

Above the carboniferous limestone is a deposit of hard coarse sandstone, sometimes called Millstone Grit; it often contains bands or seams of coal, but of small value.

The series of strata which constitute the Coal Measures, consists of three divisions [illegible] [illegible] of [illegible] and argillaceous substances, containing seams of bituminous coal [illegible] which occur in seams of from a few inches to six feet, and sometimes, though rarely, [illegible] feet in thickness; thirdly, the roof or upper bed, generally consisting of shale, often containing layers of ironstone nodules, interstratified with the shales, [illegible] [illegible] micaceous sandstone, and pebbles of other rocks, sometimes occur. The coal measures are found in a greater or lesser extent in most European countries, also in Asia, Australia, the United States, and other parts of America.

From its bituminous nature and structure, coal is presumed to be of vegetable origin, and to have been derived from luxuriant plants which grew on the spot where the seams are now found, or they were drifted into extensive estuaries and covered by beds of mud. These changes must have been repeated many times, as [illegible] by the number of beds of coal which occur one above the other, as well as their great extent. The plants found in the coal measures are chiefly ferns and other cryptogamic [illegible]



THE CARBONI

The Carboniferous is the most important group connected with the industrial resources of this and other countries. Independently of its supplying the valuable fuel coal, this series of strata contains other useful substances It is in this country the chief source of the iron ores; it also yields fire-clay, millstones, marbles, and limestones, the latter enclosing rich deposits of lead ore. The group is commonly divided into Mountain Limestone, Millstone Grit, and Coal Measures, but these are subject to local variation.

The Carboniferous or Mountain Limestone, may generally be regarded as the base of the whole Carboniferous group. In the north of England and Scotland, however, this limestone is not a uniform bed underlying the coal measures. In Ireland and other parts of Europe the limestone is separated from the Devonian Rocks by shales and sandstones. The thickness of the limestone of this period varies from a few feet to 2,000 feet; the rock is usually hard, and contains in its fissures numerous crystalline minerals, and ores of lead, zinc, and other metals.

Above the carboniferous limestone a deposit of hard coarse sandstone supervenes, called Millstone Grit; it often contains bands or seams of coal, but of small value.

The series of strata which constitute the Coal Measures, consists of first, the *under-clay* or floor, a rough argillaceous substance, containing stems of stigmaria; secondly, the *coal* which occurs in seams of from a few inches to six feet, and sometimes, though rarely, thirty feet in thickness; thirdly, the *roof* or upper bed, generally consisting of slaty clay, often containing layers of ironstone nodules. Interstratified with the shales, finely laminated clay, micaceous sand, grit, and pebbles of other rocks, sometimes occur. The coal measures are found in a greater or lesser extent in most European countries, also in Asia, Australia, the United States, and other parts of America.

From its bituminous nature and structure, coal is presumed to be of vegetable origin, and to have been derived from numerous plants which grew on the spot where the coal seams are now found, or they were drifted into ancient estuaries and covered by sand and mud. These changes must have been successively repeated over large areas, as indicated by the number of beds of coal which occur one above the other, as well as their great extent. The plants found in the coal measures are chiefly ferns and other cryptogams,

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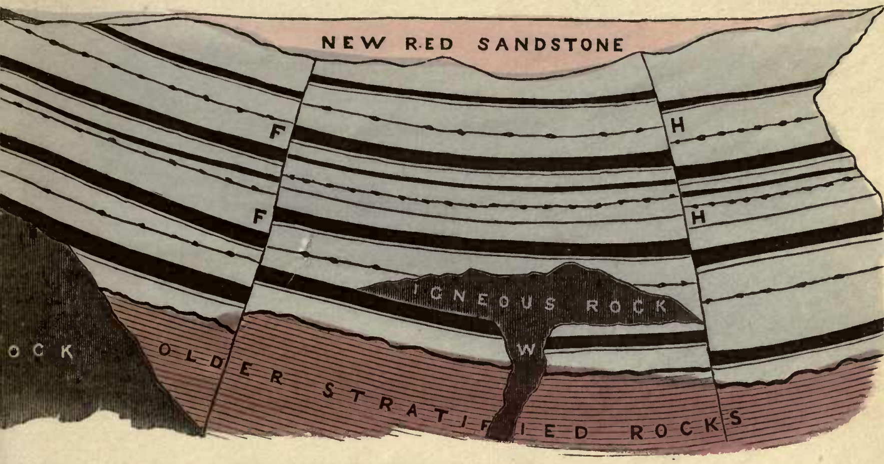


- NODULES OF CLAY IRON STONE

:ROUS GROUP.

ome coniferæ (cono-bearing), and other forms, as the lepidodendron (scaly tree), allied to ut distinct from the living Lycopodium (club mosses).

The general features of the Coal Strata will be readily perceived by an inspection of the)iagram. The fissures or fractures, often nearly vertical, and which stretch through the ntire mass, have probably been produced by the upheaving force which also converted the orizontal strata into the basin shape form. These rents are called Dykes, because they ivide the continuity of the seams or bands of coal; there are also Shifts, and still more requently, Faults or Troubles, (see F & H) by which the seam is either raised or depressed. A Dyke which does not disturb the continuity of the workable seams is called a hitch or lip. Whin Dykes (W) contain basalt or other rocks of igneous origin. Thin strata of rit or shale in the heart of a coal seam are called bands, (B). The Dykes or Faults are of he greatest importance, as the limited area contained between each two faults, provided hey be impervious to water, is thus drained with greater facility.

There are several varieties of Coal, all of which appear to have been formed by the action f certain chemical forces on wood or other vegetable matter. These varieties may for the nost part be arranged into two groups.

1st. *Anthracite*, also called glance coal or stone coal, containing no bitumen, is compact nd hard, with a high lustre.

2nd. *Bituminous Coal*, contains bitumen, comprising caking or pitching coal, cherry oal, splint, cannel, or candle coal, &c.

The following is the estimated yield per annum of the European Coal Fields.

	Tons.		Tons.
;reat Britain and Ireland	64,000,000	Spain and Portugal	60,000
'russia and Germany	8,000,000	Russia..................................	40,000
;elgium	5,500,000	Other Countries.....................	50,000
'rance	4,400,000		
ustria	2,500,000	Total for Europe	84,640,000
talian States	90,000		

The United States at the present time yield about 5.500 000 Tons.

REYNOLDS, 174. STRAND.

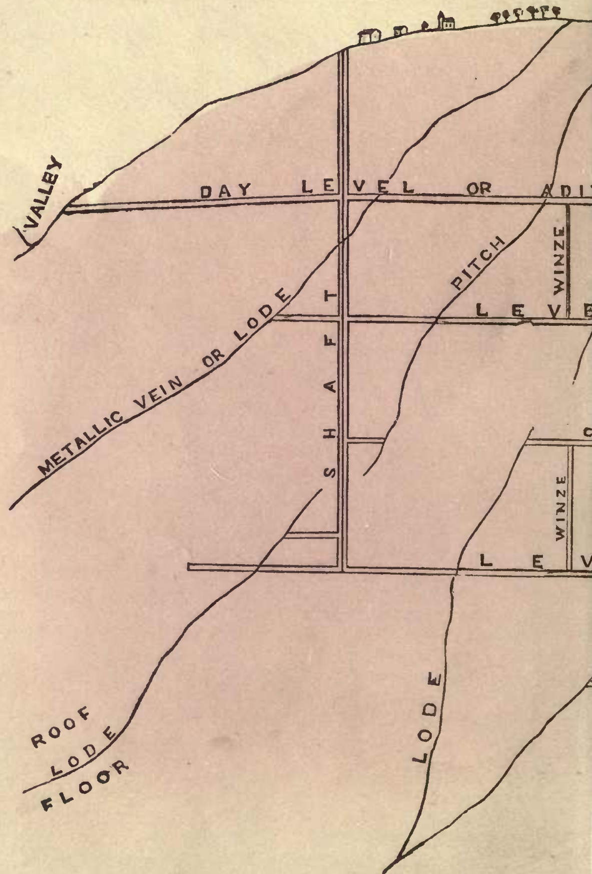
MIN

Mining is the general term applied to the exploring, working, extracting, and preparing th
distributed, and in greater or less relative abundance. Gold is frequently met with, but only
of profit. Iron is widely dispersed, and its ores occur abundantly either in regular beds or as
occur in large quantities; arsenic bismuth, nickel, cobalt, &c., although somewhat abundant,
do not occur in the same uniform manner in the various strata. Thus, coal, salt, gypsum, an
of copper and lead present occasionally a bedded appearance; but the greatest number of min
more or less at right angles to the strata. These veins may be described as fissures or crevic
consolidation of the rock, and then subsequently filled with various mineral substances. The
with a metallic ore, but is occupied with crystalline (sometimes not) minerals with which the
extracting. Veins generally dip or incline from a right angle, (see diagram) and sometim
1,500 feet from the surface.

The most abundant and extensive iron ores are those of the nodules of clay ironstone associ
found in the carboniferous limestone of some counties. Galena, or lead ore, although found i
Northumberland, &c. where it occurs in veins of different kinds, and frequently contains much silver, varying from two to eight ounces to the ton. Gold has been found in Cornwall, North Wales, and in Wicklow in Ireland. Tin is chiefly associated with the granitic and metamorphic rocks of Cornwall, but is also obtained by washing the sands and gravel of the same county, a process called 'streaming', and like that employed for obtaining gold in auriferous districts.

The chief supply of copper in England is from the ores which occur in the metamorphic schists, &c. of Cornwall and Devon. In Cornwall, the rich copper lodes run east and west. and when they meet with tin lodes pass through and sometimes heave or shift them.

The chief objects in mining are facility in extracting the ore, drainage, and ventilation. The accompanying illustration is a representation of a copper mine; the *shafts*, of which three are shown, form the principal entrance to and exit from the mine, and through which the ore is brought to the surface by means of machinery moved by horse or steam power, and also by which the water is raised to the adit or drainage level. The *adit* is driven from the lowest ground through the lodes to the perpendicular shaft,



N G.

mineral and metallic substances found in the earth's crust. These substances are variously
worked in a few localities; while the ores of silver, though less common, afford a larger source
ith earthy and other substances. Of the other useful metallic ores, lead, copper, tin, and zinc,
such great demand or generally applicable as the former. The metallic and other substances
, are found in regular beds, interstratified with the rocks in which they are imbedded; veins
its occur in veins or lodes which are not parallel to the stratification, but run in a direction
ocks, which have been produced by contraction or mechanical force after the deposition and
ns is very irregular, and of more or less limited extent; the vein is rarely if ever filled entirely
mineral is associated, and which occurs sometimes in such small quantities as not to be worth
to a great depth, as in Cornwall, where some of the mines are worked upwards of 1,000 to

he coal measures; but iron is also extensively worked from a species of hæmatite, which is
ts of Cornwall, is more abundant and characteristic of the carboniferous strata of Derbyshire,

and is the level by which the mine is drained. The *cross cuts* are passages driven from the shafts to the lodes for the purpose of exploring it, and which, when favorable indications of ore are presented, are extended on the course of the lode, and form levels. The *levels* are three feet wide and six feet in height, are about ten fathoms apart from each other in depth, and by means of which the operations of the mine are carried on, and the ore brought to the principal shafts. The portions of the veins between the levels are called *pitches*. *Winzes* are small shafts extending from one level to another. The *cheeks* or *walls*, called *roof* and *floor*, are definite partings which enclose the lode, or *hanging wall*; and *foot wall*, if the lode has considerable inclination. The *outcrop* is where the vein reaches the surface.

Summary of the Mineral Produce of the United Kingdom in 1854.

From the Mining Records.

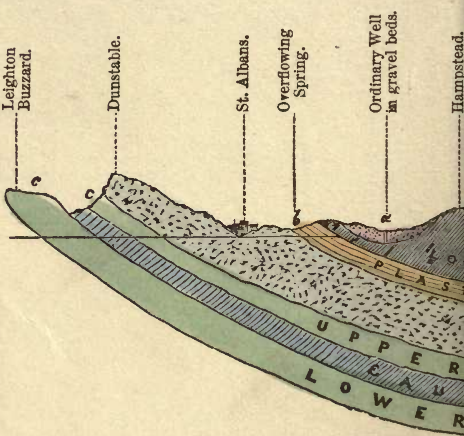
	Quantity.		*Value.*
Silver.........	700,000	oz.	£192,500
Coal...........	64,661,401	tons.	14,975,000
Iron	3,069,838	„	9,500,000
Copper........	13,042	„	1,229,807
Lead..........	64,005	„	1,472,115
Tin............	5,763	„	690,000
Zinc			16,500
Other Metals			500,000
Total Value			£28,575,922

EYNOLDS, 174, STRAND.

WATER SUPPLY

Springs and Wells. It has been roughly estimated that of the quantity of rain falling on the earth, about one-sixth is absorbed by the soil, a similar portion is carried away by rivers, &c., and the remainder is re-evaporated. Springs are either shallow or deep seated, and arise from the natural overflowing of subterranean reservoirs of water. They are of different characters, either pure or mineral, cold, hot, and even boiling, being dependent on the source from whence they come.

Wells are of two kinds, ordinary, or very deep wells; the latter being also termed Artesian, from their having been first used at Artois, in France. These two sources are well illustrated by a section of the London basin, from the north to the south of the Thames, and they depend entirely on the permeable and non-permeable character of the strata comprised within that area. Thus the ordinary or shallow wells

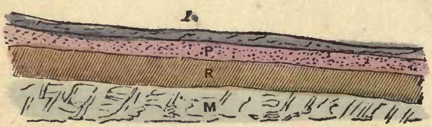


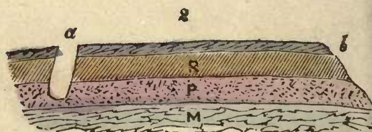
around London are formed by sinking into the sand and gravel, (as shown at *a a*) which from their permeable nature become more or less charged with water, which is retained therein as in a reservoir by the retentive nature of the thick bed of London clay immediately below it.

In the other case, that of Artesian wells, the water supply is derived from an entirelv

Rules for finding Springs. Mr. Swindell, in his work on Wells, mentions the following grass assume a brighter colour in one particular part of a field than in the remainder, or if whe found beneath it. In summer, the gnats hover in a column and remain always at a certain he dense vapours arise from those portions of the surface from which, owing to the existence of su the morning and evening. The Springs to which these rules apply are only such as are near t but to execute such operations with a chance of success, a certain knowledge of elementary G

DRAINAGE

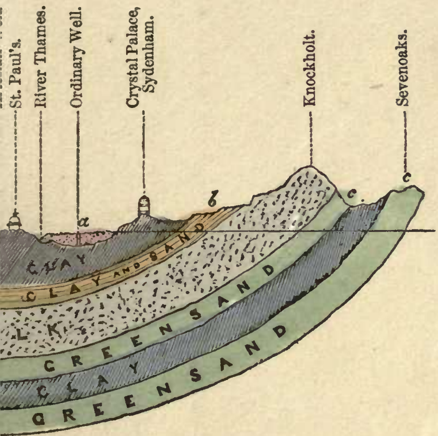




Soils may be divided into three varieties; 1, the *porous* soil, as sand, gravel, &c.; 2, the *retentive* or *impervious*, as clay, marl, dense rocks, &c.; 3, the *mixed* or *partly porous*, as loam, soft chalk, and surface soils of mixed ingredients; according to the relative positions of these several strata, so will the mode of drainage vary.

The general principles of land drainage may be exemplified by the four diagrams here shown. In the first diagram, we have an illustration where the soil immediately beneath that forming the surface is porous, the next stratum retentive, underlaid by the mixed variety. In this case, the drains must either be made with regard to the porous soils only, without interference with the clay; or the main drains must be made completely through the clay, which should be bored in the lowest or wettest places; this will bring the land into a much drier condition. Where the retentive soil lies uppermost, as represented in the second diagram, with the porous soil

ND DRAINAGE.



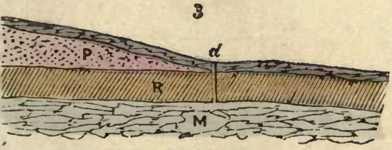
different source than that of the gravel beds before mentioned. It will be seen by the diagram, that the strata assume a basin-shaped arrangement, and that between the London clay and the chalk, is the permeable bed of sands, &c. of the plastic clay, this receives the water falling on its surface at *b b*, and is retained in it by the retentive nature of the beds above and below, and is unable to escape except at the outcrop *b*, where occasionally overflowing springs occur when the bed is fully saturated with water. If therefore a well is sunk or a boring made through the London clay into these sands, as shown in the section, water will be reached, and from the tendency to find its level, assisted by the surrounding pressure, it will sometimes rise to the surface or within a short distance of it, thus affording a supply of a pure and softer water than from ordinary wells. The fountains in Trafalgar Square,

e of the breweries and factories in London, are supplied by these wells. Similar Artesian ls may be formed by sinking still deeper into the permeable beds of the upper and lower en-sand, which outcrop at the surface at *c c*. The water of the celebrated Artesian well of nelle, at Paris, is derived from these lower cretaceous strata.

t simple rules for discovering Springs near the surface. In the early part of the year, if the er is ploughed, if a part be darker than the rest, it may be suspected that water will be the ground over the spots where springs are concealed. In all seasons of the year, more n springs, a greater degree of humidity gives rise to more copious exhalations, especially in ; when the source is lower, they are rarely sufficient, and the only safe guide is a boring; l of the arrangement of strata in the locality is absolutely necessary.

F LANDS.

3



t, it will be requisite to cut the drains through the retentive soil, and if the porous stratum hallow, through that also. In this case, if a valley exposes as at *b* the outcrop of the ous bed, the land will be more easily drained; otherwise, if a gully be cut into the porous as at *a*, the drainage can be carried to lower levels. Where a tongue of porous soil lies n a bed of clay, as shown in the third diagram, producing a swamp or morass, a main drain through the clay at the point D, will be the proper remedy.

ig. 4. This figure may afford an illustration of unequal drainage, due to the arrangement he substrata; the land over *a* will be more effectually drained in consequence of its immeely overlying the mixed porous strata, than at *b*, where it covers the retentive bed; either ace furrows to connect with the part *a*, or by boring down to M, will render the drainage orm.

DINOSAURIANS.

Pterodactyle. Iguanodon. Hylæosaurus. Megalosaurus. Teleo

GEOLOGICAL RESTORATION

The science of Palæontology treats of the history of fossils, and its principal object is to make known the forms an zoological relations of the beings which have inhabited the globe at various epochs anterior to our own. This scienc furnishes the only certain basis for the determination of the stratified rocks, and for clearing up several essential poin relative to the ancient limits of seas and continents. The presence of fossils of species which belong to the kinds essen tially fluviatile, serve to indicate the existence of land and river courses; whilst fossils of marine species prove, on th contrary, that the strata where they are deposited have been formed either near to or far from the coasts of seas different epochs. An inspection of the various strata in which fossils have been deposited shows that, in general, constant order has existed in their formation. The sea, by which the earth appears to have been covered, havin rested in certain situations a sufficient length of time to deposit particular strata, and to sustain the life of certai genera and species of animals, has undergone change; the animals of each period have become extinct, and bee successively replaced by other forms of life equally adapted to the changed conditions, whose remains are found in eac stratum, and are generally limited to, and characteristic of, one formation, although the mineral character may n always be the same.

Of the two great classes of life, the vertebrate and invertebrate, the latter are more abundant than the former; an the forms belonging to the sea far more numerous than those of freshwater. If we divide the three great series stratified rocks by the forms of vertebrate life occurring in them, we shall find that *Fishes* characterize the primar *Reptiles* the secondary; and *Mammalia* the tertiary series. Of some of these we shall offer a few illustrations.

In the primary series, the prominent vertebrate forms were fishes belonging to tribes but feebly represented in o present seas. Two genera of reptiles only have yet been met with in them, these are the Telerpeton from th Devonian beds of Scotland, and the Archegosaurus from the coal measures.

The diagram is intended to illustrate the restorations of the more remarkable forms of reptile life, whose remains a found in those formations which constitute the secondary epoch. The illustration is partly copied from a sketch Mr. Waterhouse Hawkins, F.G.S., to whose genius and industry the restorations of these animals at the Crystal Pala are due. With the lower secondary period or Trias, appeared new forms of reptilian life,—the Capitosaurus, Noth saurus, and Labyrinthodon. For some time impressions of foot prints only had been observed on some sandston belonging to the trias of Cheshire, and to which, from their form, the term Chirotherium was applied, until Profess Owen investigated and showed that the remains of the teeth and bones found in this deposit in Warwickshire, belong to a reptile allied to the Batrachian order, and from the peculiar structure of its teeth it has been named th LABYRINTHODON, and to which the footmarks were probably due.

Next in ascending order we have the group of Enaliosaurians or sea lizards, reptiles with back bones somewh resembling those of fishes, and from the structure of the air passage leading to the nostrils, they must have breath

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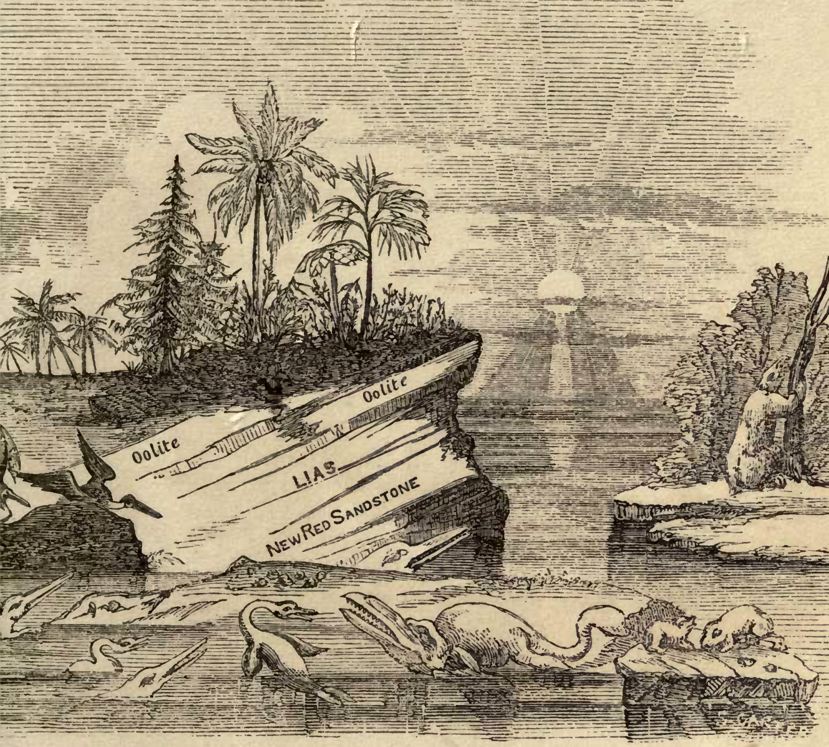


ENALIOSAURIANS.

terodactyle. Plesiosaurus. Ichthyosaurus. Labyrinthodon.

T THE CRYSTAL PALACE.

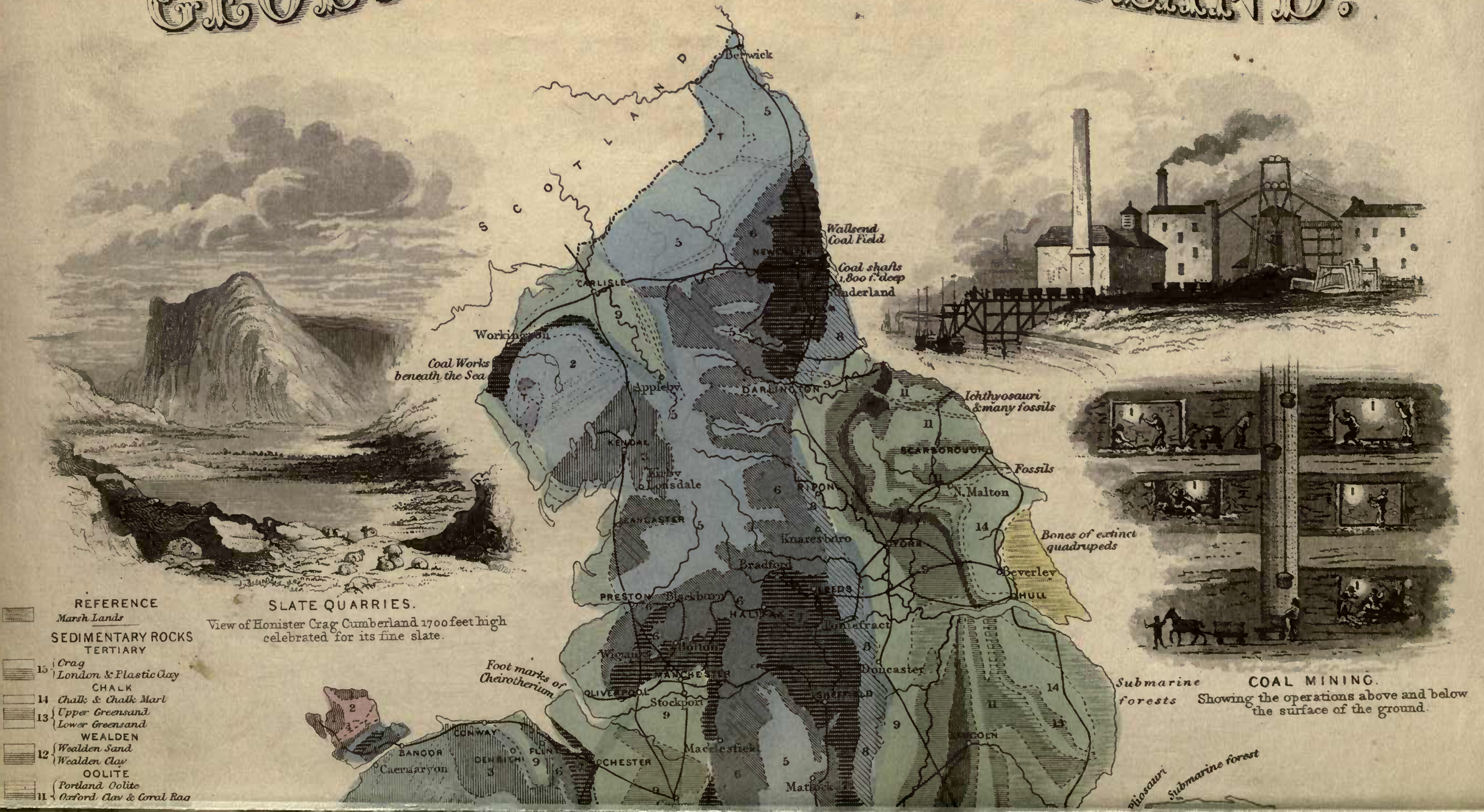
air like land quadrupeds, but were cold-blooded like the crocodiles and other reptiles. Of these are represented the HTHYOSAURUS and the PLESIOSAURUS from the Lias. The former, or fish-lizard, presents combinations of mammalian, reptile, and fish structure. The short neck and long tail distinguish it from the Plesiosaurus; its ge and peculiar eye endowed it with great powers of vision, and the wide mouth and long jaws armed with many nted teeth, indicate its carnivorous and predatory nature. The PLESIOSAURUS, another singular form from the Lias, characterized by its neck of enormous length supporting a head resembling that of the lizard, furnished with the th of a crocodile, with a trunk and tail of an ordinary quadruped, the ribs of the chameleon, and paddles similar to se of the whale. The TELEOSAURUS, found also in the Lias and Oolite, was a large extinct reptile, somewhat embling the long and slender jawed crocodile of the Ganges.

The PTERODACTYLES, or flying lizards, were covered by scales, and provided with wings, consisting of folds of n, supported on the long outer finger.

n the secondary strata, are also found another group of colossal reptiles of great magnitude and extraordinary ucture, called the Dinosaurians; the genera of this group combined both crocodilian and lacertian characters, they principally marked by the peculiar construction of their sacral and dorsal vertebræ, by the articulation of the ribs, l the modification of the teeth. Of this tribe, Professor Owen remarks, that the principal genera are the Megalo- urus, Hylæosaurus, and Iguanodon, the gigantic crocodile-lizards of the dry land; whose peculiarities of osteological ucture distinguish them as clearly from the living terrestrial and amphibious saurians, as the opposite modifications an aquatic life, characterize the extinct Enaliosaurians or marine lizards. The MEGALOSAURUS occurs in the ver oolitic strata near Oxford. The HYLÆOSAURUS and IGUANODON belong to the wealden deposits; the mer, or weald-lizard, is marked by its extraordinary dermal covering. Of the Iguanodon, Dr. Mantell states that it ualled in bulk the large herbivorous mammalia, and was as massive in its proportions, for living exclusively on getables, it must have had the abdominal region greatly developed. Its limbs must have been of proportionate size l strength to sustain and move so enormous a carcase; its hinder extremities prob bly resembled those of the popotamus, while the fore feet appear to have been less bulky, and adapted for seizing and pulling down the foliage l branches of trees; the remains of coniferous trees, arborescent ferns, and cycadeous plants, which are found bedded with its remains, attest the nature of the flora adapted for its sustenance.

The mammalia are represented by the MEGATHERIUM, a colossal sloth, whose remains occur abundantly in South nerica. This genus belonged to an extinct family of Edentata, (so named from the absence of incisor teeth) and is presented at the present day by the diminutive sloths, anteaters, and armadilloes. The gigantic fossil IRISH ELK, ich far exceeded in magnitude any living deer, has been found in the shell marl underlying the peat beds of land, and the Isle of Man; its remains have also been obtained from some parts of England.

GEOLOGICAL MAP OF ENGLAND.



THE NEEDLES ISLE OF WIGHT. An example of the destructive action of the sea upon the chalk cliffs

SECTION OF THE LINE, A-B.

...imary Series Coloured BLUE, Secondary Series GREEN, Tertiary Series YELLOW.

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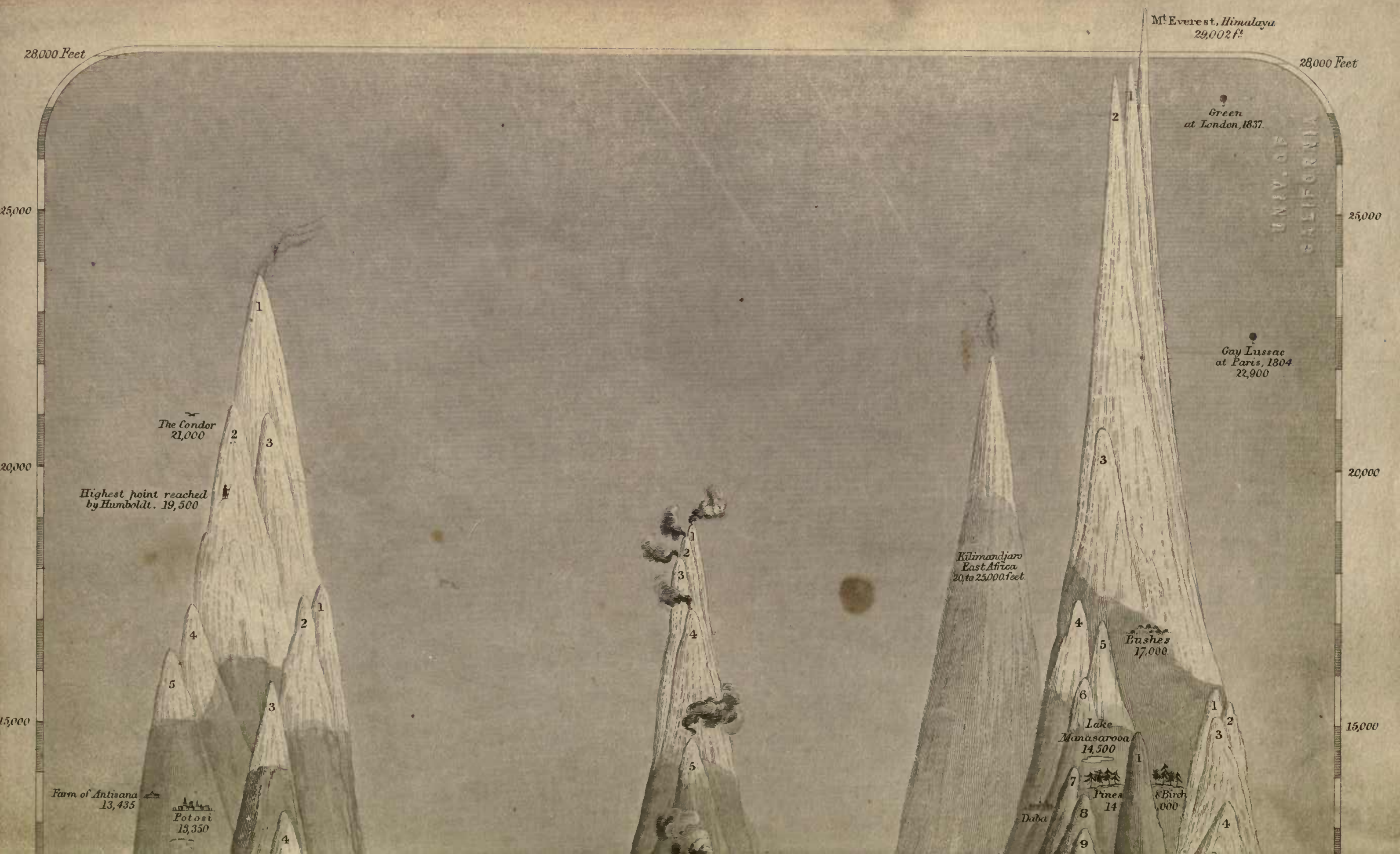
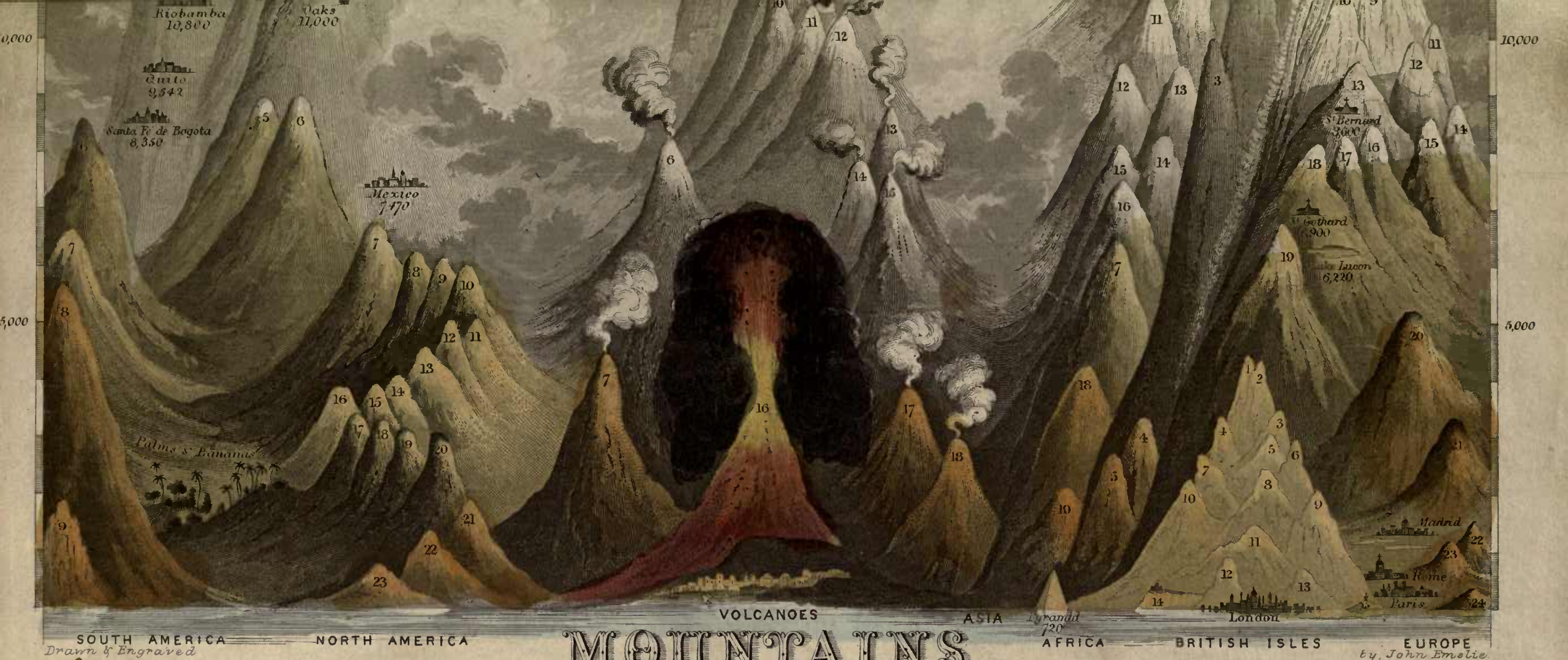


28,000 Feet
Mt Everest, Himalaya
29,002 ft
28,000 Feet
Green
at London, 1837.
25,000
25,000
Gay Lussac
at Paris, 1804
22,900
The Condor
21,000
Highest point reached
by Humboldt. 19,500
20,000
20,000
Kilimandjaro
East Africa
20 to 25,000 feet.
Bushes
17,000
15,000
15,000
Lake
Manasarova
14,500
Farm of Antisana
13,435
Potosi
13,350
Pines
14
Birch
,000
Daba



MOUNTAINS.

BRITISH ISLES.

1 Ben Nevis, *Scotland*
2 Ben Mac Dui, *Scotland*
3 Snowdon, *Wales*
4 Maigillicudy, *Ireland*
5 Skiddaw, *England*
6 Cader Idris, *Wales*
7 Cheviot, *England*
8 Plinlimmon, *Wales*
9 Ingleborough, *England*
10 Snaefell, *Isle of Man*
11 Malvern Hills, *England*
12 Arthurs Seat, *Scotland*
13 Holyhead, *Wales*
14 Dover Castle, *England*
15 Greenwich Observatory

EUROPE.

1 Mont Blanc, *Alps*
2 Mont Rosa, *Alps*
3 Ortler Speitze, *D.º*
4 Jungfrau, *Alps*
5 Mont Viso, *Italy*
6 Seirra Nevada, *Spain*
7 Nethon, *Pyrenees*
8 Perdu, *Pyrenees*
9 G.t S.t Bernard, *Alps*
10 Simplon, *Alps*
11 Pic Blanc, *France*
12 Mont Gothard, *Alps*
13 Mont Corneo, *Appennines*
14 Mont Ida, *Turkey*
15 Lomnitz, *Carpathians*
16 Orbelus, *Greece*
17 Velino, *Naples*
18 Sneehaetha, *Norway*
19 Punda, *Russia*
20 S.t Angelo, *Lipari Islands*
21 Montserrat, *Catalonia*
22 Gibraltar, *Andalusia*
23 Valdai, *Russia*
24 Mont Matre, *France*

AFRICA.

1 Abba Jared, *Abyssinia*
2 Peak, *Teneriffe*
3 Neinveldt, *C. Good Hope*
4 Table Mountain, *Ditto*
5 Dianas Peak, *S.t Helena*

ASIA.

1 Kunchinginja, *Himalaya*
2 Dhawalagira, *Himalaya*
3 Haman, *China*
4 Elburz, *Caucasus*
5 Ararat, *Armenia*
6 Mawna Roa, *Owhyhee*
7 Peak Demawund, *Persia*
8 Ophir, *Sumatra*
9 Arjish Dagh, *Asia Minor*
10 Egmont, *New Zealand*
11 Peak, *Otaheita*
12 Lebanon, *Syria*
13 Western Ghauts, *Deccan*
14 Pedrogulla, *Ceylon*
15 Melin Quantong, *China*
16 Sinai, *Arabia*
17 Sea View Hill, *N. S. Wales*
18 Ben Lomond, *V. D. Land*
19 Carmel, *Palestine*

NORTH AMERICA.

1 S.t Elias, *Russian Amer.*
2 Popocatapetl, *Mexico*
3 M.t Browne, *Rocky Mountains*
4 Fremont Peak, *Ditto*
5 Sierra de Cobre, *Cuba*
6 Senania Grand, *Domingo*
7 M.t Washington, *U. States*
8 Stony Mountains, *Ditto*
9 White Mountains, *Ditto*
10 Blaarserk, *E Greenland*
11 Morn Grove, *S.t Vincent*
12 Souffriere, *Guadaloupe*
13 Moose Hillock, *U. States*
14 Pelee, *Martinique*
15 Camels Hump, *U. States*
16 Saddle Mount, *Ditto*
17 Kattskill, *New York*
18 Killington Peak, *U. States*
19 Monadnoch, *U. States*
20 Allegheny, *U. States*
21 Appallachian, *U. States*
22 M.t Edgecombe, *N. Ame.*
23 Potatoe Hills, *U. States*

SOUTH AMERICA.

1 Aconcagua, *Andes Chili*
2 Chimboraso, *Andes*
3 Sorata, *Andes*
4 Illiniza, *Andes Bolivia*
5 Nevada Merida, *Columbia*
6 Caraccas, *Venezuela*
7 Guadarama, *Columbia*
8 Itocolumi, *Brazil*
9 Cape Horn, *Terra del Fuego*

VOLCANOES.

1 Antisano, *Quito*
2 Cotopaxi, *Quito*
3 Arequissa, *Peru*
4 Orizaba, *Mexico*
5 Tanguragua, *Quito*
6 Blue Mountains, *Jamaica*
7 Jorulla, *Mexico*
8 Gunong Demp, *Sumatra*
9 Koriats Raia, *Kamstchatka*
10 Etna, *Sicily*
11 Krionats, *Kamstchatka*
12 Schwelatsh, *Ditto*
13 Awatska, *Kamstchatka*
14 Fogo, *Fogo*
15 Voliano, *Bourbon*
16 Vesuvius, *Naples*
17 Hecla, *Iceland*
18 Stromboli, *Lipari Islands*

PHYSICAL MA

FROM THE DISCOVERIES OF THE

Drawn & Engraved

THIS MAP *is intended to enable the eye to perceive at a Glance the great Physical*
Elevated *and* Table lands *by the darker the* Mountains *by the darkest, the* Deserts
greater velocity, and the arrows showing the direction of the current. The Warı
perature of the Air *is shown by the Isotherms, or waving lines crossing the Ma*
mean annual temperature. An observation of the Arctic Current, and the Gulf

Published by James

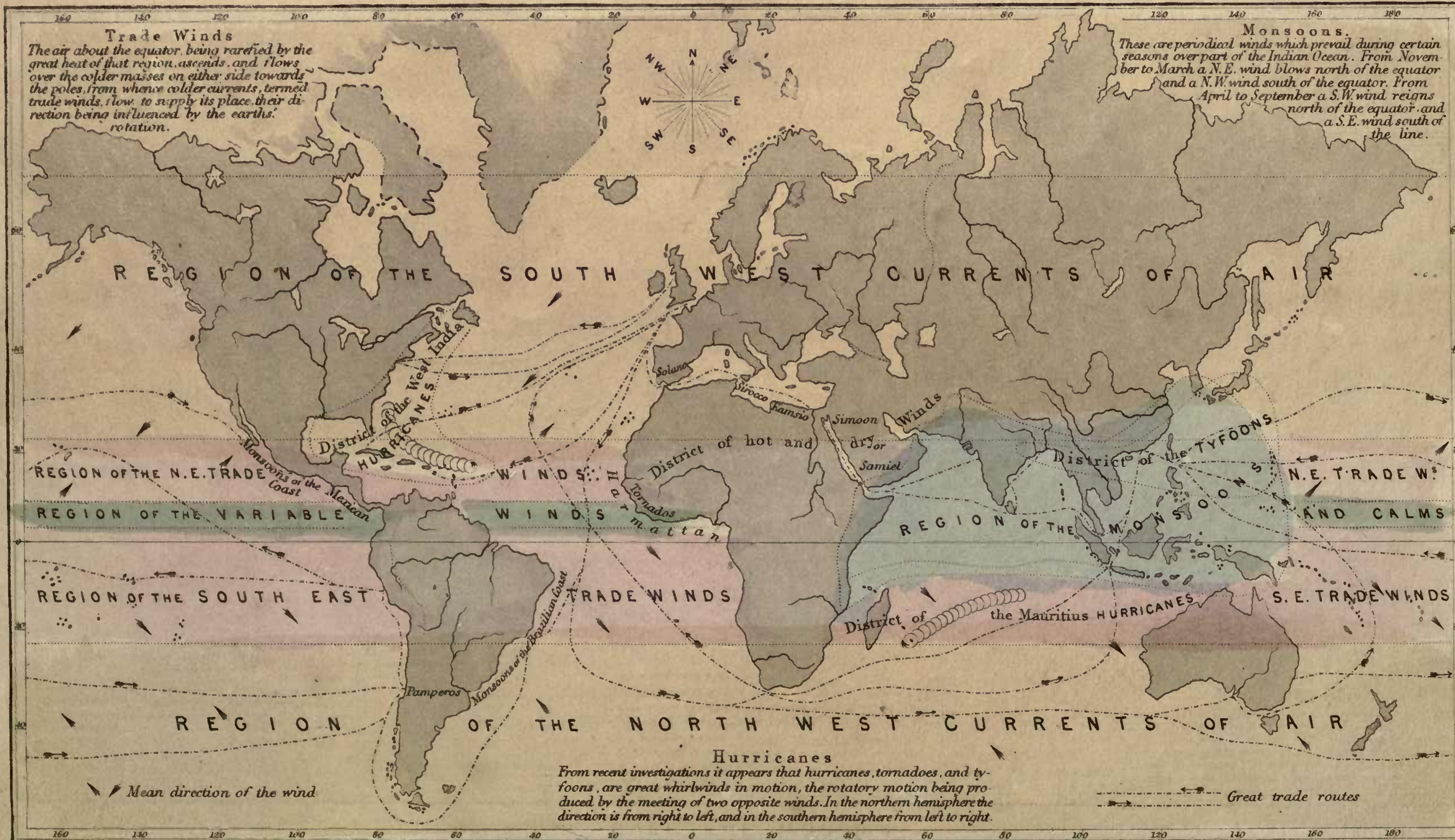
OF THE WORLD.

MINENT MODERN GEOGRAPHERS.

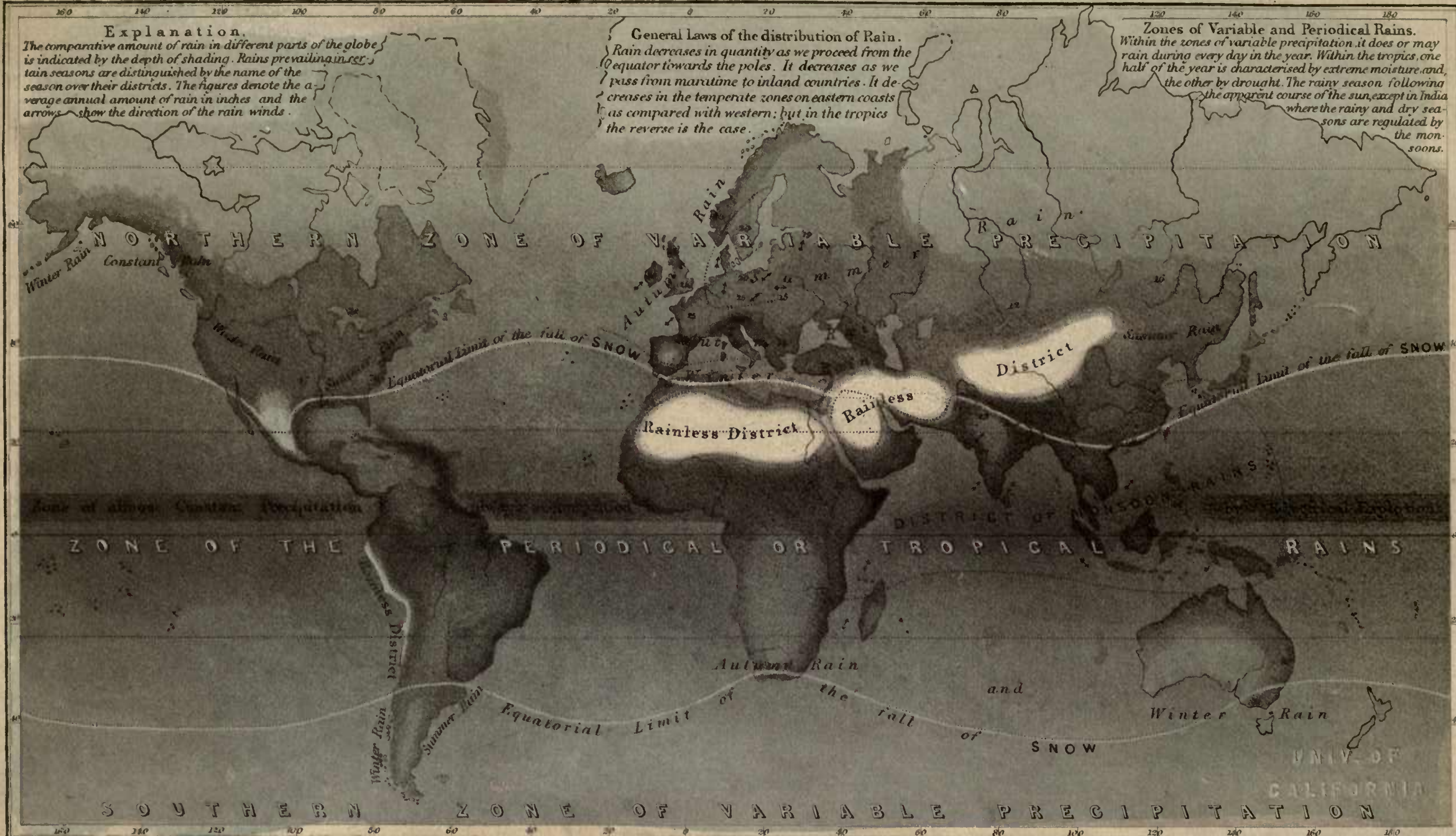
the Surface of the globe. In the Continents, the Lowlands are marked by the light tint, the ing. In the Ocean, the Currents are shown by fine lines, the deeper shading indicating the aters is shown by figures indicating the degree of Fahrenheit at those spots. The tem each end the degree of Fahrenheit, all places situated on these lines having the same how the great influence of those currents upon the climate of the neighbouring Countries.

Strand London Dec^r 10^th 1849

DISTRIBUTION OF THE CURRENTS OF AIR AND VARIABLE WINDS OVER THE WORLD.



OVER THE WORLD.

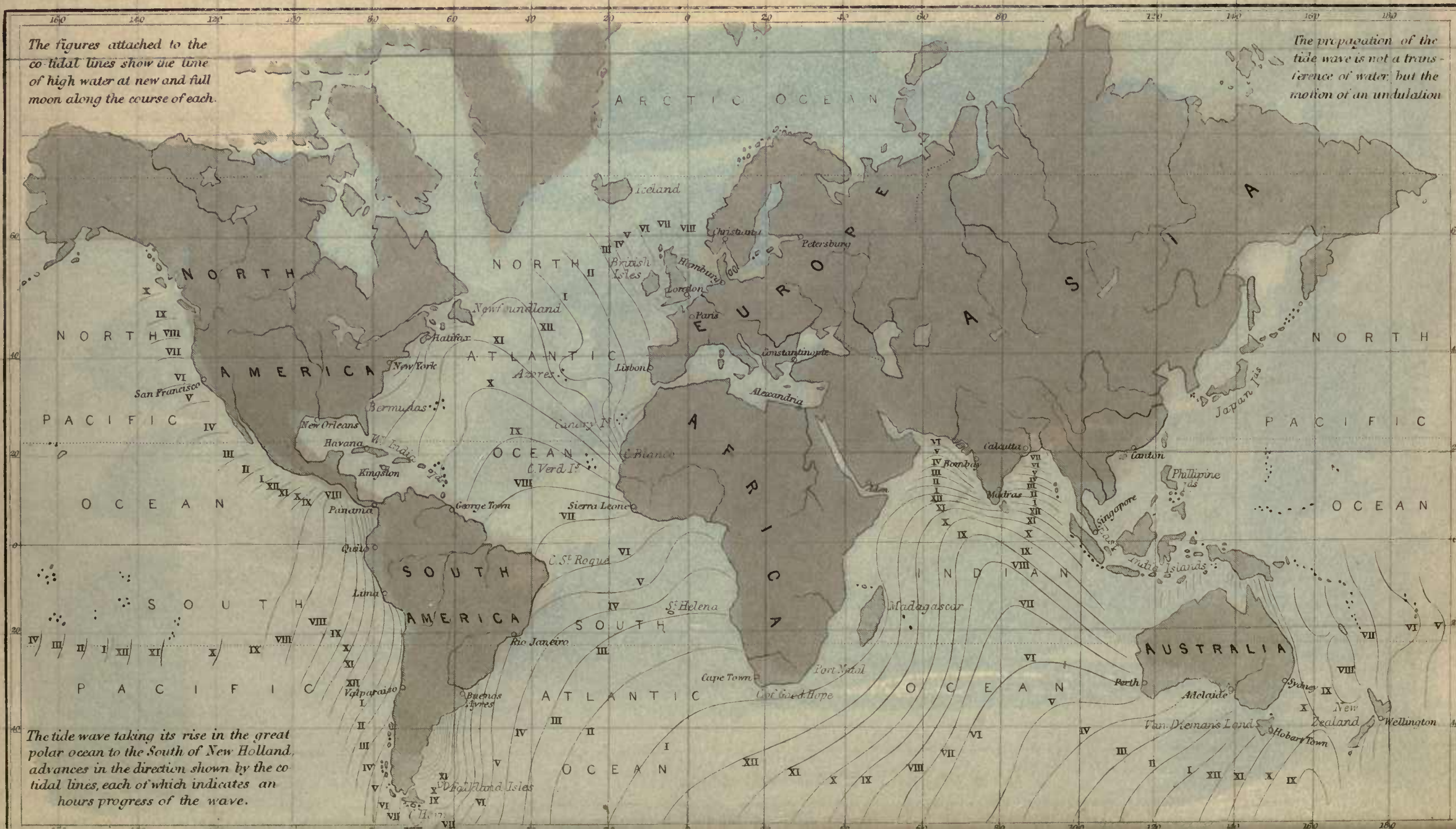


Drawn & Engraved by John Emslie

Published by James Reynolds 174 Strand London.

TIDAL CHART OF THE WORLD.

SHOWING THE PROGRESS OF THE WAVE OF HIGH WATER.



THE DISTRIBUTION OF PLANTS
AND THEIR CULTIVATION OVER THE WORLD.

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ZOOLOGICAL MAP SHOWING

THE DISTRIBUTION OF ANIMALS

OVER THE WORLD.

OVER THE WORLD.

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PHEN

VOLCANOES AN

SHOWING THE INFLUENCE EXERTED BY THE HEA

1 Hecla, Iceland.
2 Peak Teneriffe, Canary Is.
3 Stromboli, Lipari Is.
4 Vesuvius, Naples.
5 Etna, Sicily.

6 Demavend, Persia.
7 Bourbon, Indian Ocean.
8 Peshan, Tartary.
9 Singallang, Sumatra.
10 Merapi .... Do. ....

11 Someero, Java.
12 Tumbora, Sia
13 Mahave, Luzon
14 Fusi, Japan.
15 Khaitchewskaja,

N A OF

EARTHQUAKES.

RIOR OF THE EARTH UPON ITS EXTERNAL SURFACE.

Mt Egmont, New Zealand	21 Jorullo, Mexico.	26 Arequipa, Peru.
... Edgecumbe, ... Do	22 Coseguina, Guatemala	27 Antuco, Chile.
Mauna Loa, Sandwich Is.	23 Cotopaxi, Quito.	28 Yantales, Do
Tobreonou, Society Is.	24 Tunguragua, Do	29 Blue Mountains, Jamaica
Popocatepetl, Mexico.	25 Gualatieri, Peru.	30 Mt Erebus, Antarctic Sea.

Drawn & Engraved by John Emslie

[illegible]

PHYS

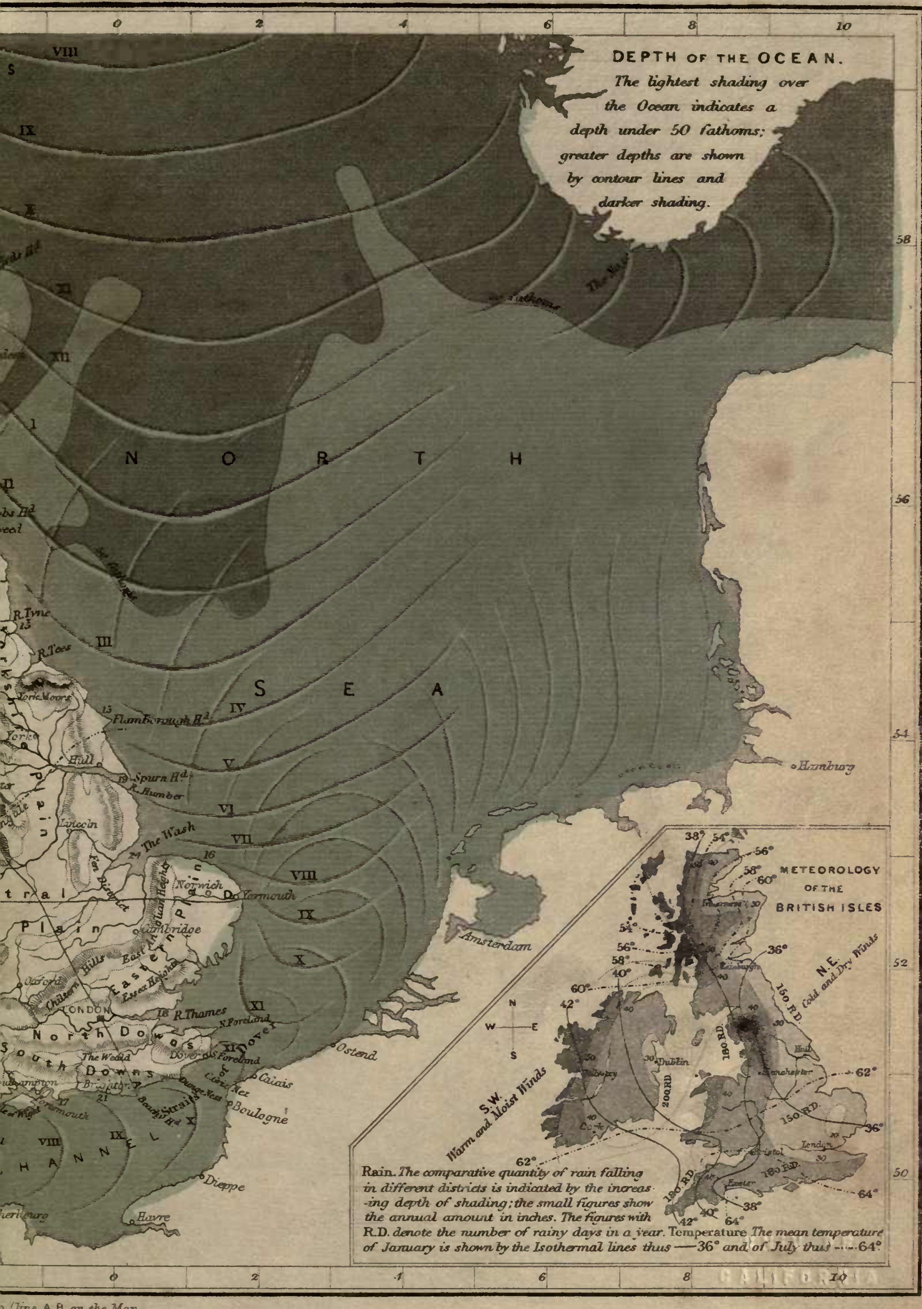
THE BRITISH ISLES AN

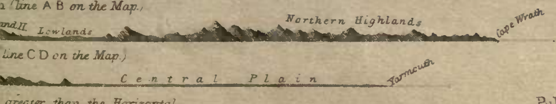
Drawn & Engraved by John Emslie.

The Vertical Scale on these

AP OF

E SURROUNDING SEAS.





Published by J. Reynolds 174 Strand Decr 13th 1851.

RANUNCULACEÆ.

Fig. 1.
CROWFOOT.

MAGNOLIACEÆ.

Fig. 2.
MAGNOLID.

ANONACEÆ.

Fig. 3.
CUSTARD APPLE.

NYMPHACEÆ.

Fig. 4.
WATER-LILY.

NELUMBIACEÆ.

Fig. 5.
SACRED BEAN.

PAPAVERACEÆ.

Fig. 6.
POPPY.

RESEDACEÆ.

Fig. 7.
WELD.

FLACOURTIACEÆ.

Fig. 8.
ARNOTTO.

DROSERACEÆ.

Fig. 9.
VENUS'S FLY TRAP.

POPULAR SKETCH

OF

THE VEGETABLE KINGDOM.

SHOWING THE

CLASSIFICATION OF PLANTS ACCORDING TO THE NATURAL SYSTEM,

WITH THEIR LOCALITIES, PROPERTIES, AND USES.

COMPILED FROM THE WORKS OF LINDLEY, BALFOUR, &c.

PHANEROGAMOUS, OR VASCULAR FLOWERING PLANTS.

EXOGENS.

The largest class in the Vegetable Kingdom. It is distinguished by the following characteristics:—1. The Wood is exogenous, that is, increases in bulk by the addition of new wood on the *outside* of the old wood, between it and the bark. 2. The Veins of the Leaves are netted, and the leaves are joined to the stem, so that when dead they separate readily at the joint. 3. The Flowers have their parts arranged in fours or fives, or some multiple of those numbers. 4. The Seeds have usually two lobes, as in the Bean, Almond, &c., rarely more, as in the Firs, but never one.

THALAMIFLORÆ.

Having Calyx and Corolla; Petals distinct, and inserted into the thalamus; Stamens hypogynous.

1. **Ranunculaceæ**, Crowfoots. Herbs, or rarely shrubs, found in cold, damp climates. These plants are all, more or less, acrid and poisonous. Lindley enumerates 41 genera, and 1,000 species. (See Fig. 1.)

2. **Dilleniaceæ**, Dilleniads. Trees, shrubs, or undershrubs, found chiefly in Australia, India, and the warm parts of America. They have astringent properties, and some species are used for tanning purposes; others afford valuable timber. There are 26 genera, and 200 species.

3. **Magnoliaceæ**, Magnoliads. Fine trees or shrubs, abounding in North America, and found also in South America, Australia, China, and Japan. Lindley notices 11 genera, and 65 species. These plants have, in general, a bitter tonic taste, and fragrant flowers. Some species yield by distillation an aromatic oil, similar to the oil of anise; and others are valuable for their timber. (Fig. 2.)

4. **Anonaceæ**, Anonads, or Custard Apple Family. Trees or shrubs of tropical countries. Their properties are usually aromatic and fragrant; some species yield edible fruits, and others a kind of pepper. The lancewood of coachmakers is furnished by a plant of this order. Lindley mentions 20 genera, including 300 species. (Fig. 3.)

5. **Menispermaceæ**, Menispermads, or Moonseeds. Twining shrubs, common in tropical countries. There are, according to Lindley, 44 known genera, and 302 species. The properties of these plants are, in general, bitter and narcotic; some are tonic and others poisonous. Among the former is the root of *Cocculus palmatus*, or Columba-root, a valuable bitter tonic; among the poisonous species is *Anamirta cocculus*, the fruit of which is known as *Cocculus indicus*

6. **Berberidaceæ**, Berberids. Shrubs or herbaceous perennial plants, found chiefly in the mountainous parts of the north temperate regions. Their properties are bitter and acid. The bark and stem of the common Berberry supplies a yellow dye, and the fruit is used as a preserve. Lindley gives 12 genera, and 100 species.

7. **Cabombaceæ**, Watershields. American aquatic plants, with floating peltate leaves. Their properties are slightly astringent. Lindley notices 2 genera, and 3 species.

8. **Nymphaceæ**, Waterlillies. Aquatic plants, growing in quiet waters. These plants are mostly confined to the northern hemisphere. The properties of some are astringent and bitter, others are sedative, and some contain starch. Their flowers are universally admired. *Victoria regia*, the beautiful lily of South America, is one of the largest of known aquatics. Its odoriferous flowers are more than a foot in diameter, and its leaves from four to six feet in diameter. Lindley notices 5 genera, and 50 species. (Fig. 4.)

9. **Nelumbiaceæ**, Waterbeans. Aquatic herbs, with large and beautiful flowers. Found in quiet waters, in both temperate and tropical regions, but most abundant in

India. Their nuts are wholesome, and the root or creeping stem is used as food in China. 1 genus, and 3 species. (Fig. 5.)

10. **Sarraceniaceæ**, SARRACENIADS, or SIDE-SADDLE Family. Herbaceous plants, found in boggy places in North America and Guayana. Their uses are unknown. 2 genera, and 7 species.

11. **Papaveraceæ**, POPPYWORTS. Herbaceous plants or shrubs, often with a milky juice. These plants are chiefly European, but are found also in tropical America, Asia, Australia, and at the Cape of Good Hope. Their properties are narcotic. Opium is procured from the capsules of *Papaver somniferum*, and its varieties. The seeds of the Opium Poppy yield a bland, wholesome oil, which is largely used on the Continent. Lindley enumerates 18 known genera, and 130 species. (Fig. 6.)

12. **Fumariaceæ**, FUMEWORTS. Herbaceous plants, with brittle stems and a watery juice. Found chiefly in the north temperate climates. Their properties are bitter and diaphoretic. Lindley gives 15 genera, and 110 species.

13. **Cruciferæ**, CRUCIFERS. Herbaceous plants, found in all parts of the world. These plants possess in general antiscorbutic and stimulant qualities. To this order belong many of the common culinary vegetables, as Cabbages, Cauliflower, Turnip, Radish, Cress, &c. Lindley enumerates 173 genera, including 1,600 species.

14. **Capparidaceæ**, CAPPARIDS. Herbs, shrubs, and sometimes trees. Found chiefly in warm countries, and abundant in Africa. There are 28 genera, and 340 species. These plants have stimulant and pungent qualities. *Capparis spinosa* furnishes capers.

15. **Resedaceæ**, RESIDADS or WELDWORTS. Herbaceous plants, chiefly inhabiting Europe, and the adjoining parts of Asia. There are 6 genera, and 41 species. *Resida luteola*, called Weld (Fig. 7), yields a yellow dye, and *Resida odorata* is the fragrant Mignionette.

16. **Flacourtiaceæ**, BIXADS. Shrubs or small trees, chiefly natives of the warmest parts of the East and West Indies, and Africa. Many of these plants furnish edible fruit, some are astringent, and others purgative. The red dye, Arnotto, is obtained from the pulp surrounding the seeds of *Bixa orellano* (Fig. 8). Lindley enumerates 31 genera, and 85 species.

17. **Cistaceæ**, ROCK-ROSES. Shrubs or herbaceous plants of the southern parts of Europe and the north of Africa. Some of the plants yield a resinous balsamic juice. There are 7 known genera, and 185 species.

18. **Violaceæ**, VIOLETWORTS. Herbaceous plants or shrubs, natives of Europe, Asia, and America. There are 14 genera, and 315 species. The roots of these plants possess emetic properties.

19. **Droseraceæ**, SUNDEWS. Herbaceous plants of morasses and marshy places. There are 8 known genera, and upwards of 90 species. The *Droseras* have an acid taste, and some are said to be poisonous to cattle; others have dyeing properties. *Dronæa muscipula*, or Venus's Fly Trap, is a North American plant, having the laminæ of the leaves in two halves, each furnished with irritable hairs, which, on being touched, cause the folding together of the divisions (Fig. 9).

20. **Polygalaceæ**, MILKWORTS. Shrubs or herbs, sometimes twiners, found in most parts of the world. They are generally bitter, and their roots yield a milky juice. Snake-root and Rhatany-root, used in medicine, are obtained from plants belonging to this order. Lindley mentions 19 genera, and 495 species.

21. **Tremandraceæ**, POREWORTS. Slender heath-like shrubs, natives of Australia. There are 3 genera, with 16 species. Nothing is known of their properties.

22. **Tamaricaceæ**, TAMARISKS. Shrubs or herbs, found in the vicinity of the Mediterranean. Their bark is bitter and astringent, and some, when burned, yield sulphate of soda. Lindley mentions 3 genera, including 43 species.

23. **Franckeniaceæ**, FRANKENIADS. Herbs or under shrubs, found chiefly in Southern Europe and Northern Africa. They have mucilaginous and slightly aromatic properties. 4 genera, 24 species.

24. **Elatinaceæ**, WATER-PEPPERS. Annual marsh plants, with hollow creeping stems, found in all parts of the world. Some of them have acrid properties. There are 6 genera, and 22 species.

25. **Caryophyllaceæ**, SILENADS or CLOVEWORTS. Herbs, and sometimes suffruticose plants, chiefly of temperate and cold regions. Most of these plants are weeds, but some are admired garden flowers, as the pink, carnation, &c. Lindley mentions 53 genera, and 1,055 species.

26. **Vivianaceæ**, VIVIANADS. Herbaceous or suffruticose plants of South America, having no properties of importance. 4 genera, 15 species.

27. **Malvaceæ**, MALLOW-WORTS. Herbaceous plants, trees, or shrubs. Found chiefly in tropical countries, and in the warm parts of the temperate zone. All these plants are wholesome, and generally yield much mucilage. Some furnish materials for

MALVACEÆ.

Fig. 10.
HERBACEOUS COTTON.

MALVACEÆ.

Fig. 11.
SEA ISLAND COTTON.

MALVACEÆ.

Fig. 12.
GREEN SEED COTTON.

STERCULIACEÆ.

Fig. 13.
THE BAOBAB.

STERCULIACEÆ.

Fig. 14.
MONKEY'S BREAD.

BYTTNERIACEÆ.

Fig. 15.
CHOCOLATE NUT.

TILIACEÆ.

Fig. 16.
LIME.

TILIACEÆ.

Fig. 17.
JUTE.

TERNSTRŒMIACEÆ.

Fig. 18.
TEA PLANT.

AURANTIACEÆ.

Fig. 19.
CITRON.

AURANTIACEÆ.

Fig. 20.
LIME.

AURANTIACEÆ.

Fig. 21.
SHADDOCK.

GUTTIFERÆ.

Fig. 22.
GAMBOGE PLANT.

GUTTIFERÆ.

Fig. 23.
MANGOSTEEN.

ACERACEÆ.

Fig. 24.
SUGAR MAPLE.

SAPINDACEÆ.

Fig. 25.
HORSE CHESTNUT.

RHIZOBOLACEÆ.

Fig. 26.
SUWARROW NUT.

CEDRELACEÆ.

Fig. 27.
MAHOGANY TREE.

cordage, and others supply cotton, &c. Cotton is composed of the hairs surrounding the seeds of various species of *gossypium*. (See Figs. 10, 11, and 12). Lindley enumerates 37 genera, including 1,000 species.

28. **Sterculiaceæ**, STERCULIADS. Trees or shrubs of warm climates. These plants are mucilaginous and demulcent; many are used for food, and others supply a material like cotton. *Adansonia digitata*, the Baobab tree of Senegal (Fig. 13), is one of the most ancient of trees. Its trunk has been found with a diameter of thirty feet, and the age of some specimens is calculated at 5,000 years. The pulp of its fruit, called Monkey's bread (Fig. 14), is used as an article of food. Lindley mentions 34 genera, and 125 species.

29. **Byttneriaceæ**, BYTTNERIADS. Trees, shrubs, or undershrubs, abounding in tropical countries. These plants are highly mucilaginous, and many supply materials for cordage. The seeds of *Theobroma Cacao*, or Cacao-beans (Fig. 15), furnish the chief ingredient in chocolate. Lindley mentions 45 genera, and 400 species.

30. **Tiliaceæ**, LINDEN-BLOOMS. Trees or shrubs found chiefly in tropical countries (Fig. 16). Lindley enumerates 35 genera, including 350 species. These plants possess mucilaginous properties, and many supply excellent cordage material, as Jute. (Fig. 17.)

31. **Dipterocarpaceæ**, DIPTERADS. Gigantic trees, abounding in resinous juice, found in India and the East Indian Islands. There are about 8 known genera, and 48 species. A kind of camphor is yielded by *Dryobalanops Camphora*. Indian copal, the *Gum animi* of commerce, is procured from *Vateria Indica;* this tree also yields the Butter of Canara, or Pinei Tallow.

32. **Chlænaceæ**, CHLÆNADS. Trees or shrubs found in Madagascar. Their properties are unknown. There are 4 genera, and 10 species.

33. **Ternstrœmiaceæ**, THEADS, or TEAS. Trees or shrubs abounding in South America, India, China, and North America. There are 33 genera, and 130 species. The most important plants of this order are those which yield Tea. The black and green teas of the northern districts of China are obtained from the same species, namely, that known in Britain as the *Thea viridis*, while the black and green teas from the Canton district are made from the variety known as *Thea Bohea* (Fig. 18).

34. **Olacaceæ**, OLACADS. Trees or shrubs, chiefly tropical or sub-tropical. Little is known of their properties. Balfour gives 24 genera, and 53 species.

35. **Aurantiaceæ**, CITRONWORTS. Trees or shrubs, remarkable for their beauty. They abound in the East Indies, and are found in other warm regions. There are 20 genera, and 95 species. The plants of this order secrete a fragrant bitter and volatile oil, and the fruit has a more or less acid pulp. The orange, lemon, citron, shaddock, and lime belong to this order. (Figs. 19, 20, 21.)

36. **Hypericaceæ**, TUTSANS. Herbaceous plants, shrubs, or trees. They are distributed generally over the globe, being found in elevated and low, dry and damp situations. They yield a resinous juice having purgative properties. There are, according to Lindley, 13 known genera, and 276 species.

37. **Guttiferæ**, GUTTIFERS. Trees or shrubs, sometimes parasitical, and natives of tropical regions, especially of South America. Lindley enumerates 30 genera, comprising 150 species. These plants yield a yellow resinous juice, which is acrid and purgative. Gamboge, employed medicinally and as a pigment, and the Mangosteen, a fruit of the Spice Islands, are produced by plants of this order. (Figs. 22 and 23.)

38. **Marcgraviaceæ**, MARGRAVIADS. Trees or shrubs, sometimes climbing, occurring chiefly in the warm parts of America. Their properties are unimportant. There are 4 genera, and 26 species.

39. **Hippocrateaceæ**, HIPPOCRATEADS. Arborescent or climbing shrubs. Found principally in South America, while a few are natives of Africa and the East Indies. The fruit of some is edible. Lindley gives 6 genera, including 86 species.

40. **Erythroxylaceæ**, ERYTHROXYLS. Shrubs or trees, found chiefly in the West Indies and South America. Their qualities are tonic, purgative, and narcotic; some yield a reddish-brown dye. There are 3 genera, and 80 species.

41. **Malpighiaceæ**, MALPIGHIADS. Trees or shrubs, of tropical countries chiefly, a great number of them being found in South America. Lindley mentions 42 genera, comprising 555 species. Many of these plants are astringent, and some have stinging hairs.

42. **Aceraceæ**, MAPLES. Trees, which are confined chiefly to the temperate parts of the globe. They yield a saccharine sap, from which sugar is sometimes manufactured (Fig. 24). There are three genera, and 60 species.

43. **Sapindaceæ**, SOAPWORTS. Trees or shrubs, and sometimes climbing herbaceous plants. They are natives principally of South America and India. Lindley notices 50 genera, and 380 species. In this order are included the Horse-chesnuts (Fig. 25).

Many of the plants yield edible fruits, while others are poisonous. The fruit of *Sapindus saponaria* is used as a substitute for soap in the West Indies.

44. **Rhizobolaceæ**, RHIZOBOLS. Large trees, of the warm forests of South America. Some yield edible nuts, known as Suwarrow nuts (Fig. 26), from which an oil is extracted equal in quality to that of the Olive. Lindley mentions 2 genera, and 8 species.

45. **Meliaceæ**, MELIADS. Trees or shrubs, found chiefly in the tropical parts of America and Asia. There are 40 known genera, and upwards of 160 species. The plants of this order possess bitter, tonic, and astringent qualities. Oils are procured from some species, and others yield a fragrant balsam.

46. **Cedrelaceæ**, CEDRELADS. Trees, of the tropical parts of America and Asia. There are 9 genera, including 25 species. The plants of this order are bitter and fragrant. *Swietenia Mahogani* (Fig. 27) supplies the well-known mahogany wood; and *Chloroxylon Swietenia*, satin-wood.

47. **Vitaceæ**, VINEWORTS. Climbing shrubs, inhabiting the milder and hotter parts of the globe, and abounding in the West Indies. There are 7 genera, and 260 species. The fruit of these plants, when ripe, is saccharine. The Grape Vine belongs to this order. (Fig. 28.)

48. **Geraniaceæ**, CRANESBILLS. Herbs or shrubs, distributed over various parts of the world. The plants of this order are astringent and aromatic; some of the species, as Geranium and Pelargonium, are remarkable for the beauty of their flowers. (Fig. 29.) There are 4 genera, and 500 species.

49. **Linaceæ**, FLAXWORTS. Annual and perennial plants, scattered over the globe, but most abundant in Europe, and in the north of Africa. There are 3 genera, including 90 species. These plants yield mucilage and fibre. Flax is procured from the inner bark of the stalk of *Linum usitatissium* (Fig. 30). The seeds yield Linseed oil.

50. **Balsaminaceæ**, BALSAMS. Succulent herbaceous plants, with watery juice and showy flowers. They are found chiefly in the East Indies. Their properties are unimportant. Lindley mentions 3 genera, comprising 110 species.

51. **Oxalidaceæ**, OXALIDS, or WOOD SORRELS. Herbs, undershrubs, or trees, found in the hot and temperate parts of the globe, and abundant in North America and at the Cape of Good Hope. There are 6 known genera, and 320 species. Some are acid in their properties; others yield esculent roots.

52. **Tropæolaceæ**, INDIAN CRESSES. Herbaceous trailing or twining plants, with gay flowers. Natives of the temperate parts of America. Their fruit is used as a cress, or pickled and used as capers. Lindley enumerates 6 genera, including 44 species.

53. **Pittosporaceæ**, PITTOSPORADS. Trees or shrubs, found chiefly in Australia. Many of them are resinous, and of some species the berries are edible. Lindley mentions 12 genera, and 78 species.

54. **Brexiaceæ**, BREXIADS. Trees, existing chiefly in Madagascar. Lindley enumerates 4 genera, including 6 species.

55 **Zygophyllaceæ**, BEAN CAPERS. Herbs, shrubs, or trees, occurring in various parts of the globe, chiefly in warm regions. Lindley mentions 7 genera, including 100 species. Some of the plants abound in a stimulant resin; others are bitter and acrid. *Guaiacum officinale* is a beautiful West Indian tree, yielding the hard and heavy wood called Lignum-vitæ. (Fig. 31.)

56. **Rutaceæ** RUEWORTS. Trees or shrubs, found chiefly in the south temperate zone. There are 48 genera, and 400 species. These plants have a peculiar odour; many possess anti-spasmodic properties; and others are bitter, and act as febrifuges and tonics.

57. **Xanthoxylaceæ**, XANTHOXYLS. Trees or shrubs of the tropical parts of America. Lindley mentions 20 genera, comprising 110 species. The plants yield an aromatic, pungent, and volatile oil; some are diaphoretic in their properties, others are febrifugal and tonic.

58. **Simarubaceæ**, QUASSIADS. Trees or shrubs, found in the tropical regions of America, Asia, and Africa. 10 genera, and 35 species. These plants are all intensely bitter. Quassia is used medicinally as a tonic, and frequently by brewers as a substitute for hops.

59. **Ochnaceæ**, OCHNADS. Undershrubs or trees, growing in tropical countries. They are mostly bitter, and some of them are used as tonics. Lindley enumerates 6 genera, comprising 82 species.

60. **Coriariaceæ**, CORIARIADS. Shrubs found in small numbers in the south of Europe, South America, India, and New Zealand. Some of them are poisonous. 1 genus, 8 species.

CALYCIFLORÆ.

Calyx and Corolla present; Petals distinct; Stamens attached to the Calyx.

61. **Stackhousiaceæ**, STACKHOUSIADS. Shrubs found in Australia, without any marked properties. 2 genera, 10 species.

VITACEÆ.

Fig. 28.
THE VINE.

GERANIACEÆ.

Fig. 29.
GERANIUM

LINACEÆ.

Fig. 30.
FLAX PLANT.

ZYGOPHYLLACEÆ.

Fig. 31.
LIGNUM VITÆ.

ANACARDIACEÆ.

Fig. 32.
CASHEW NUT.

ANACARDIACEÆ.

Fig. 33.
MANGO.

ANACARDIACEÆ.

Fig. 34.
HOG PLUM.

LEGUMINOSÆ.

Fig. 35.
SENNA PLANT.

LEGUMINOSÆ.

Fig. 36.
LIQUORICE PLANT.

LEGUMINOSÆ.

Fig. 37.
LOGWOOD TREE.

LEGUMINOSÆ.

Fig. 38.
INDIGO PLANT.

ROSACEÆ.

Fig. 39.
ALMOND.

RHIZOPHORACEÆ.

Fig. 40.
MANGROVE TREE.

MYRTACEÆ.

Fig. 41.
ALLSPICE.

MYRTACEÆ.

Fig. 42.
POMEGRANITE.

MYRTACEÆ.

Fig. 43.
GUAVA.

MYRTACEÆ.

Fig. 44.
MALAY APPLE.

CUCURBITACEÆ.

Fig. 45.
GOURDS.

62. **Celastraceæ**, SPINDLE-TREES. Small trees or shrubs found in the warm parts of Europe, North America, and Asia; and also at the Cape of Good Hope. There are 24 genera, and 260 species. These plants have sub-acrid properties, and the seeds of some yield a useful oil; others are considered poisonous. The bark of *Enonymus tingens* furnishes a yellow dye.

63. **Staphyleaceæ**, BLADDER-NUTS. Shrubs scattered over various parts of the globe. Some of them are sub-acrid, and others bitter and astringent. They are cultivated as handsome shrubs. 3 genera, and 14 species.

64. **Rhamnaceæ**, BUCKTHORNS. Trees or shrubs, distributed generally over the globe, and found both in temperate and tropical regions. There are 42 genera, and 250 species. Many of these plants have active cathartic properties; some yield edible fruit, and others are tonic and febrifugal.

65. **Anacardiaceæ**, ANACARDS. Trees or shrubs with a resinous and often caustic juice. They are found chiefly in the tropical parts of the world. There are 41 genera, and 95 species. Many of these plants supply varnishes. *Anacardium occidentale* furnishes the edible Cashew-nut. Although a resinous principle pervades the plants of this order, yet, in some cases, it is not developed in the fruit, which becomes eatable, as exhibited in the Mango and the Hog-plums of the West Indies. (Figs. 32, 33, 34.)

66. **Amyridaceæ**, AMYRIDS. Trees or shrubs abounding in resin, and natives of tropical regions. Lindley mentions 22 genera, and 45 species. The plants yield a fragrant balsamic and resinous juice, which, when dry, is often used as frankincense, and is employed medicinally as a stimulant and expectorant.

67. **Connaraceæ**, CONNARADS. Trees or shrubs of the tropics, and possessing febrifuge properties. Lindley notices 5 genera, and 41 species.

68. **Leguminosæ**, PEA and BEAN Tribe. Herbaceous plants, shrubs, or trees. The plants of this order are very generally distributed over the globe. The number of known genera, according to Lindley, is 467, comprehending 6,500 species. This extensive and important natural order embraces many valuable medicinal plants, as those yielding senna, gum-arabic, catechu, &c.; important dyes, as indigo and logwood; many valuable timber trees, as locust-tree and rosewood; and food plants, as the bean and pea. The properties of the order are in general wholesome, although it contains some poisonous plants. (Figs. 35, 36, 37, 38.)

69. **Moringaceæ**, MORINGADS. Trees of the East Indies and Arabia. Some of them have pungent and aromatic qualities. The seeds of *Moringa pterygosperma*, the horse-radish tree, are winged, and are called Ben-nuts; from these is procured a fluid oil, used by watchmakers, and called Oil of Ben. Lindley notices 1 genus, and 4 species.

70. **Rosaceæ**, ROSEWORTS. Herbaceous plants, shrubs, or trees, found chiefly in the cold and temperate climates of the northern hemisphere. There are 82 known genera, and about 1,000 species. Many of the plants yield edible fruits, as Strawberries, Plums, Apples, Cherries, Almonds, &c. (Fig. 39). Some are astringent, others yield hydrocyanic acid.

71. **Calycanthaceæ**. CALYCANTHS. Shrubs with square stems, and natives of North America and Japan. Their flowers are aromatic, and the bark of some is used as a carminative. The order includes 2 genera, and 6 species.

72. **Lythraceæ**, LOOSESTRIFES. Herbs and shrubs, natives of Europe, North and South America, and India. Lindley mentions 35 genera, and 300 species. Many of the plants have astringent qualities, and some are used for dyeing.

73. **Rhizophoraceæ**, MANGROVES. Trees or shrubs found on the muddy shores of the tropics. There are 5 genera, and 20 species known. Some of these plants have an astringent bark, which is used for dyeing black. *Rhizophora Mangle*, the Mangrove-tree, forms thickets at the muddy mouths of rivers, and sends out adventitious roots which raise the trunk above its original level, giving the tree the appearance of being supported upon stalks. The fruit is sweet and edible (Fig. 40).

74. **Vochysiaceæ**, VOCHYADS. Trees or shrubs, inhabiting the warmer parts of America. Their properties are imperfectly known. There are 8 genera, and 51 species.

75. **Combretaceæ**, MYROBALANS. Trees or shrubs, natives of the tropics. Their properties are astringent, many are used for tanning, and some for dyeing. Lindley enumerates 22 genera, including 200 species.

76. **Melastomaceæ**, MELASTOMADS. Trees, shrubs, or herbs, found chiefly in warm climates. The plants are wholesome, and the succulent fruit of several is edible. They possess slight astringent qualities. Lindley mentions 118 genera, including 1,200 species.

77. **Alangiaceæ**, ALANGIADS. Trees or shrubs, found chiefly in India; some, however, are natives of America. Lindley enumerates 3 genera, including 8 species. Some of the plants yield edible fruits, others are purgative.

78. **Philadelphaceæ**, SYRINGAS. Shrubs, natives of the south of Europe, of North

America, Japan, and India. They have no important properties. There are 3 genera, and 25 species.

79. **Myrtaceæ**, Myrtles. Trees or shrubs, natives of warm climates, but many are found in temperate regions, while some of the genera are peculiar to Australia. There are 77 known genera, and upwards of 1,400 species. Many of these plants yield an aromatic volatile oil; many supply edible fruits; and others furnish astringent and saccharine substances. The leaves of some species are used as tea in Australia. The species of *Eucalyptus* constitute the gigantic gum trees of Australia, some of which attain a height of 200 feet. (Figs. 41, 42, 43, 44.)

80. **Onagraceæ**, Evening Primroses. Herbs or shrubs, of temperate regions chiefly. Some yield edible fruits, and others edible roots. Many of them possess mucilaginous properties, while a few are astringent. There are about 30 known genera, and upwards of 450 species.

81. **Halorageaceæ**, Mares-tails. Herbs or undershrubs, often aquatic, and found in ditches and lakes in various parts of the world. They have no properties of importance. 8 genera, 70 species.

82. **Loasaceæ**, Chili Nettles. Herbaceous plants, natives of America, and distinguished for their stinging qualities. 15 genera, and 70 species.

83. **Cucurbitaceæ**, Cucurbits. Herbaceous plants, with succulent stems. They are natives of warm climates chiefly, and abound in India. 60 genera, and about 300 species. These plants are acrid, and many of them are drastic purgatives. In some cases, however, the fruits are eatable, as the Melon, Cucumber, Gourd, and Vegetable Marrow. (Fig. 45.)

84. **Papayaceæ**, Papayads. Trees or shrubs, found in South America, and other warm countries. The Papaw-tree (Fig. 46) yields an acrid milky juice, which has the property of rendering tough meat tender; and an edible fruit. There are 11 genera, and 29 species.

85. **Belvisiaceæ**, Belvisias, or Napoleon-worts. Shrubs, of the tropical regions of Africa chiefly. There are 2 genera, and 4 species. Some are used as astringents.

86. **Passifloraceæ**, Passion-flowers. Herbs or shrubs, natives chiefly of warm climates. There are 14 known genera, and 215 species. Many of the plants yield edible fruits; others are bitter and astringent; and some narcotic (Fig. 47).

87. **Turneraceæ**, Turnerads. Herbaceous or shrubby plants, natives of the West Indies, and South America. Their properties are unimportant. Lindley notices 2 genera, including 60 species.

88. **Portulacaceæ**, Purslanes. Succulent shrubs or herbs found in various parts of the world. They have few properties of importance. There are 12 genera, and 184 species.

89. **Paronychiaceæ**, Knotworts. Herbaceous or shrubby plants, found in barren places in various parts of Europe, Asia, and North America. Their properties are unimportant. 28 genera, 120 species.

90. **Crassulaceæ**, Houseleeks. Herbaceous plants or shrubs, often succulent, found in the driest situations, as on rocks, walls, &c., in various parts of the world. 25 genera, 460 species.

91. **Ficoideæ**, Ficoids. Herbaceous or shrubby succulent plants, found generally in warm regions. There are 16 known genera, and 440 species. Some are used as food; others yield soda.

92. **Cactaceæ**, Cactuses. Succulent shrubs, with peculiar angular or flattened stems, and usually without leaves. They grow in hot, dry, and exposed places, and are natives chiefly of the tropical parts of America. There are 16 genera, and about 800 species. These plants are remarkable for their succulence, for their great development of cellular tissue, and the anomalous forms of their stems. Many yield a refreshing edible fruit (Fig. 48).

93. **Grossalariaceæ**, Gooseberry and Currant Tribe. Shrubs of temperate regions, many of which yield edible fruits. 3 genera, 100 species.

94. **Saxifragaceæ**, Saxifrages. Trees, shrubs, or herbs, of temperate climates. There are 57 genera, and upwards of 900 species. Few of the plants are put to any use.

95. **Bruniaceæ**, Bruniads. Branched heath-like shrubs, natives chiefly of the Cape of Good Hope, with no important properties. 15 genera, 65 species.

96. **Hamamelidaceæ**, Witch-hazels. Shrubs or small trees, found in various parts of Asia, Africa, and America. The seeds of *Hamamelis virginica* are used as food. 10 genera, 15 species.

97. **Umbelliferæ**, Umbellifers. Herbaceous plants, often with hollow and furrowed stems. Found chiefly in the northern hemisphere. There are 267 genera, including 1,500 species. The properties of these plants are various. Some yield food, others gum, resinous, and oily substances, while others are highly poisonous. The species have been grouped into four divisions: 1. The esculent species, as the Carrot, Parsnip, Celery, Parsley, &c. 2. Those producing milky juices, which concrete into a

PAPAYACEÆ.

Fig. 46.
Papaw.

PASSIFLORACEÆ.

Fig. 47.
Passion Flower.

CACTACEÆ.

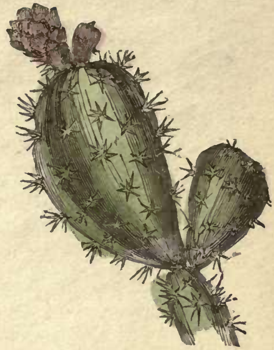


Fig. 48.
Cactus-tuna.

UMBELLIFERÆ.

Fig. 49.
Hemlock.

RUBIACEÆ.

Fig. 50.
Peruvian Bark.

RUBIACEÆ.

Fig. 51.
Coffee Plant.

RUBIACEÆ.

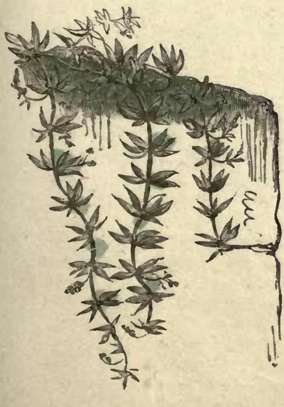


Fig. 52.
Madder.

DIPSACACEÆ.

Fig. 53.
Teazel.

COMPOSITÆ.

Fig. 54.
Safflower.

ERICACEÆ.

Fig. 55.
Rhododendron.

SAPOTACEÆ.

Fig. 56.
Gutta Percha Plant.

OLEACEÆ.

Fig. 57.
Olive.

OLEACEÆ.

Fig. 58.
Ash.

GENTIANACEÆ.

Fig. 59.
Gentian.

BIGNONIACEÆ

Fig. 60.
Trumpet Flower.

CONVOLVULACEÆ.

Fig. 61.
Jalap Plant.

SOLANACEÆ.

Fig. 62.
Tobacco Plant.

SOLANACEÆ.

Fig. 63.
Love Apple.

SCROPHULARIACEÆ.

Fig. 64.
FOX-GLOVE.

POLYGONACEÆ.

Fig. 65.
BUCK WHEAT.

LAURACEÆ.

Fig. 66.
CAMPHOR.

LAURACEÆ.

Fig. 67.
CINNAMON PLANT.

LAURACEÆ.

Fig. 68.
CLOVE.

MYRISTICACEÆ.

Fig. 69.
NUTMEG.

EUPHORBIACEÆ.

Fig. 70.
EUPHORBIA.

EUPHORBIACEÆ.

Fig. 71.
CASTOR OIL PLANT.

EUPHORBIACEÆ.

Fig. 72.
INDIA-RUBBER PLANT.

GRAMINEÆ.

Fig. 133.
SUGAR CANE.

RHIZANTHÆ.

Fig. 134.
RAFFLESIA.

EQUISETACEÆ.

Fig. 135.
EQUISETUM.

FILICES.

Fig. 136.
TREE FERNS.

LYCOPODIACEÆ.

Fig. 137.
CLUB MOSS,

LICHENES.

Fig. 138.
ORCHIL.

FUNGI.

Fig. 139.
MUSHROOMS.

ALGÆ.

Fig. 140.
IRISH MOSS SEA-WEED.

fetid gum-resin, as Assafœtida, Ammoniac, Galbanum, &c. 3. Those species which supply a carminative and aromatic oil, as Carraway-seeds, Anise, Coriander, &c. 4. The poisonous species include Hemlock, Water Dropwort, &c. (Fig. 49.)

98. **Araliaceæ**, Ivyworts. Trees, shrubs, or herbaceous plants, found both in tropical and in cold regions. Lindley enumerates 21 genera, comprising 160 species. These plants are allied to Umbelliferæ, and have generally aromatic and stimulant properties. Some species of *Aralia* yield an aromatic gum-resin.

99. **Cornaceæ**, Cornels. Trees, shrubs, or herbs, of temperate climates. The bark of some species is used as a tonic and febrifuge; the seed of *Cornus mascula* has been used as food; and the seeds of *Cornus sanguinea* furnish oil. 9 genera, and 40 species.

COROLLIFLORÆ.

Calyx and Corolla present; Petals united, bearing the Stamens.

100. **Loranthaceæ**, Loranths, or Mistletoes. Shrubs, usually parasitical. Many in the tropical regions have showy flowers, which hang from the branches of trees, presenting a beautiful appearance. Lindley mentions 23 genera, and 412 species. The bark is astringent.

101. **Caprifoliaceæ**, Caprifoils, or Honeysuckle Tribe. Shrubs or herbs, chiefly found in the temperate climates. There are 14 genera, and 220 species. Many of the plants have odoriferous flowers, and some possess emetic and purgative properties. The fruit of the common Elder is used in the manufacture of Elder Wine.

102. **Rubiaceæ**, Cinchonads. Trees, shrubs, or herbs. The order has been divided into two sub-orders: 1. Cinchoneæ, natives of the warm regions; and 2. Galieæ, or Stellatea, natives of colder regions. There are nearly 280 genera, and upwards of 2,800 known species. The properties of these plants are, in general, tonic, febrifuge, and astringent; some, however, have emetic and purgative qualities, as Ipecacuanha. Among the food plants of this order the most important is *Coffea arabica*, the Coffee plant, a native of Arabia. The Madder of commerce, used in dyeing, is produced by the root of *Rubia tinctoria*. (Figs. 50, 51, 52.)

103. **Valerianaceæ**, Valerian-worts. Herbs, of temperate climates. These plants are strong-scented or aromatic, and some of them are employed as bitter tonics and anti-spasmodics. There are 12 genera, and 185 species.

104. **Dipsacaceæ**, Teazels. Herbs or undershrubs, found in the south of Europe, the Levant, and at the Cape of Good Hope. Their properties are unimportant. The heads of *Dipsacus fullonum*, Fuller's Teazel (Fig. 53), on account of their spiny bracts, are used in dressing cloth. Lindley notices 6 genera, including 150 species.

105. **Calyceraceæ**, Calycers. Herbaceous plants of South America. Their properties are unknown. 5 genera, 10 species.

106. **Compositæ**, Composites. Herbs or shrubs. This is one of the largest families in the vegetable kingdom. De Candolle's division of the order, now generally adopted, is as follows: 1. Tubulifloræ; 2. Labratifloræ; 3. Liguliforæ. The plants of this order are variously distributed over the globe. In northern regions they are mostly herbaceous, while in warm climates they become shrubby or even arborescent. Their properties are more or less bitter, and sometimes astringent, acrid, and narcotic. In this order is comprised the following well-known plants and vegetable products: Artichoke, Thistle, Camomile, Wormwood, Southernwood, Sunflower, Lettuce, and Safflower. (Fig. 54.) There are 1,000 genera, and 9,500 species.

107. **Brunoniaceæ**, Brunoniads. Stemless herbaceous plants, natives of Australia. Their properties are unknown. 1 genus, 9 species.

108. **Goodeniaceæ**, Goodeniads. Herbs, found in Australia and the South Sea Islands. Some are eaten as pot-herbs. 14 genera, and 150 species.

109. **Stylidiaceæ**, Styleworts. Non-lactescent herbs or undershrubs, natives of marshy places in Australia. Some are also found at the southern extremity of South America. 5 genera, and 121 species.

110. **Campanulaceæ**, Bellworts. Lactescent herbs or undershrubs, natives chiefly of northern and temperate regions. The milky juice found in the plants of this order has acrid properties. There are, according to Lindley, 28 genera, and 500 species.

111. **Lobeliaceæ**, Lobeliads. Lactescent herbs or shrubs, found both in temperate and warm climates. Acridity is their prevailing characteristic. *Lobelia inflata*, Indian Tobacco of North America, is used medicinally as a sedative and expectorant. The milky juice of some species of this order contains Caoutchouc. There are 27 known genera, including 375 species.

112. **Gesneraceæ**, Gesnerworts. Herbs or shrubs, found chiefly in the warmer regions of America. Their properties are unimportant. There are 22 known genera, and upwards of 120 species.

113. **Ericaceæ**, Heaths. Shrubs, undershrubs, or herbaceous plants, with evergreen leaves. The order has been divided into—1. Ericeæ, the true Heaths and

Rhododendrons, with scaly conical buds; 2. Monotropeæ, including the true Monotropas, or Fir-rapes; and Pyroleæ, or the Wintergreen tribe. There are 52 genera, and nearly 880 species. The order contains many beautiful plants, which abound at the Cape of Good Hope, and are also found in other parts of the world. The fruits of some of these plants are eatable, as *Gaultheria procumbeus*, and *Shallon*, American shrubs; others have poisonous narcotic properties, as many species of Rhododendron, Azalea, &c. (See Fig. 55.)

114. **Vacciniaceæ**, CRANBERRIES. Shrubby plants, closely allied to Ericaceæ. They are natives of temperate regions, and some of them are marsh plants. Some are astringent, others yield sub-acid edible fruits. There are 15 genera, and 200 species.

115. **Epacridaceæ**, EPACRIDS. Shrubs or small trees, allied to Ericaceæ, and occupying the place of heaths in Australia. Their flowers are beautiful, and some yield edible fruits. 30 known genera, 320 species.

116. **Columelliaceæ**, COLUMELLIADS. Evergreen shrubs or trees, natives of Mexico and Peru. Properties unknown. 1 genus, 3 species.

117. **Styracaceæ**, STORAX-WORTS. Trees or shrubs, natives chiefly of warm climates. Lindley mentions 6 genera, and 115 species. These plants are in general stimulant, aromatic, and fragrant. Some of them yield balsamic resinous substances, as storax, benzoin, &c., and others dyeing material.

118. **Ebenaceæ**, EBENADS. Trees or shrubs, found chiefly in the tropical regions and India. These plants are remarkable for the hardness and durability of their wood. Some yield edible fruit. Lindley notices 9 genera, and 160 species.

119. **Aquifoliaceæ**, HOLLYS. Evergreen trees, or shrubs, found in various parts of the world. Their properties generally are astringent and tonic. The leaves and bark of the holly are tonic and febrifuge, while its berries are emetic and purgative. Its wood is white and hard, and is esteemed in turnery and cabinet work. Lindley enumerates 11 genera, including 110 species.

120. **Sapotaceæ**, SAPOTADS. Lactescent trees or shrubs, natives of the tropical parts of India, Africa, and America. Many of the plants yield edible fruits, while others supply oily matter. The milky juice of some of the plants contains elastic matter, as Gutta Percha, which is obtained from *Isonandra Gutta* (Fig. 56). There are 21 known genera, and 212 species.

121. **Myrsinaceæ**, ARDISIADS. Trees, shrubs, or undershrubs, found chiefly in the islands of Africa, Asia, and America. Little is known of their properties. 31 known genera, and 325 species.

122. **Jasminaceæ**, JASMINES. Shrubs, often with twining stems, abounding chiefly in the tropical parts of India. Their flowers yield fragrant oil, and their leaves and roots are sometimes bitter. 5 genera, 100 species.

123. **Oleaceæ**, OLIVES. Trees or shrubs, found chiefly in temperate regions. There are two sections of this order: 1, Oleæ, with a drupaceous, or berried fruit; 2, Fraxineæ, with a samaroid, or winged fruit. Lindley notices 24 genera, including 130 species. These plants are bitter, tonic, and astringent, and some yield oil. *Olea Europæa* is the Olive-tree of the coast of the Mediterranean and south of Europe. The oil of commerce is obtained by expression from the fleshy pericarp of the fruit (Fig. 57). Several species yield a sweet exudation, called Manna. The flowering Ash is a native of the south of Europe, where it attains a height of twenty or thirty feet. The common Ash (Fig. 58), attains a much greater height; its wood is tough and elastic, and is used for oars, &c. To this order also belongs *Syringa vulgaris*, the common Lilac, and *Ligustrum vulgare*, common Privet.

124. **Asclepiadaceæ**, ASCLEPIADS. Shrubs or herbs, with a milky juice, often twining. Inhabitants chiefly of tropical regions, but many species extend to northern climates. There are 141 genera, and 910 species. These plants have acrid, purgative, emetic, and diaphoretic properties. The milky juice is generally bitter and acrid, but sometimes it is bland, and is used as milk. The milky juice of many of the plants contains Caoutchouc.

125. **Apocynaceæ**, DOGBANES. Trees or shrubs, usually lactescent, found chiefly in tropical regions. Lindley enumerates 100 genera, including 566 species. Many of the plants are poisonous; some are used medicinally as cathartics; and a few yield edible fruits. The juice of *Tabernæmontana utilis*, the Cow-tree of Demerara, is used as milk. Many of the plants supply Caoutchouc; and some species yield a dye like Indigo.

126. **Loganiaceæ**, LOGANIADS. Shrubs, herbs, or trees of tropical and warm climates chiefly. The order is divided into three sub-orders:—1, Loganieæ; 2, Strychneæ; 3, Spigelieæ. There are about 24 known genera, and nearly 170 species. The plants of this order are highly poisonous, and possess also narcotic properties. It includes *Strychnos Nux-Vomica*, the Poison-nut, from which Strychnia is obtained.

127. **Gentianaceæ**, GENTIAN-WORTS. Herbs, and occasionally shrubs, distributed

URTICACEÆ.

Fig. 73.
Hemp.

URTICACEÆ.

Fig. 74.
Elm.

URTICACEÆ.

Fig. 75.
Mulberry.

URTICACEÆ.

Fig. 76.
Black Mulberry.

URTICACEÆ.

Fig. 77.
Bread Fruit.

URTICACEÆ.

Fig. 78.
Fig.

URTICACEÆ.

Fig. 79.
Banian Tree

generally over the globe. There are two sub-orders: 1. Gentianeæ; 2. Menyantheæ. The general property of these plants is bitterness, and they are used as tonics. Lindley mentions 60 genera, including 450 species. (Fig. 59.)

128. **Bignoniaceæ,** BIGNONIADS, or Trumpet-flower Family. Trees, shrubs, or herbs, of tropical regions chiefly. The order has been divided into four sub-orders: 1. Bignoniæ; 2. Cyrtandreæ; 3. Crescentieæ; 4. Pedalieæ. There are upwards of 100 known genera, and about 650 species. This order comprises many showy plants; some are timber trees, others furnish dyes and articles of diet, and a few have bitter and astringent qualities. (Fig. 60)

129. **Polemoniaceæ,** PHLOX-WORTS. Herbaceous or climbing plants, of temperate climates generally, abounding in the north-west of America. There are 17 genera, and 104 species. Many of these plants have showy flowers, and some are remarkable for their development of spiral cells.

130. **Hydrophyllaceæ,** HYDROPHYLLS. Trees, shrubs, or herbs, of America chiefly. Their properties are unimportant. Many have showy flowers, and some have stinging hairs. The order has been divided into two sub-orders: 1. Hydrophylleæ; 2. Diapensieneæ. There are 18 known genera, and 77 species.

131. **Convolvulaceæ,** BINDWEEDS. Herbs or shrubs, usually twining, sometimes parasitical, and with a milky juice. They occur chiefly in tropical and temperate regions. The order has been divided into two sub-orders: 1. Convolvuleæ, true Bindweeds, leafy plants; 2. Cuscuteæ, leafless parasites. There are 45 genera, and upwards of 700 species. The roots of many of these plants possess an acrid juice, which, having purgative properties, is used medicinally. To this order belong the Jalap plant, *Convolvulus Jalapa* (Fig. 61), and the Scammony plant, *Convolvulus Scammonia.* The roots of some species are used as food, as *Batatas edulis*, the sweet Potato.

132. **Cordiaceæ,** SEBESTENS. Trees, natives chiefly of warm countries. Some yield edible fruit; their bark is occasionally bitter, tonic, and astringent. There are 11 genera, and 180 species.

133. **Boraginaceæ,** BORAGE-WORTS. Herbs, shrubs, or trees. The order has been divided into three sub-orders: 1. Boragineæ, natives chiefly of temperate climates; 2. Ehretieæ, of tropical climates; 3. Heliotropieæ, of both warm and temperate countries. There are 67 known genera, and nearly 900 species. These plants are generally mucilaginous and emollient. Some are astringent, others yield nitrate of potash.

134. **Solanaceæ,** NIGHTSHADES. Herbs or shrubs, natives of most parts of the world, but most abundant in the tropics. The order has been divided into two sub-orders: 1. Rectembryæ; 2. Curvembryæ. There are 66 known genera, and 935 species. These plants have, in general, narcotic properties, and some are very poisonous. In some species, certain parts of the plant have poisonous properties, while other parts are harmless, and are used as food. Thus *Solanum tuberosum*, the Potato, has slight narcotic properties in its leaves and fruit, but in the tubers there is an abundance of starch, and when cooked they are wholesome and nutritious. To this family belong Belladonna, Henbane, &c., also the Tobacco plant, *Nicotiana Tabacum* (Fig. 62), a native of the hotter parts of North and South America. The species of *Capsicum*, supplying Cayenne pepper and Chillies, and *Lycopersicum esculentum*, the Tomato, or Love Apple (Fig. 63), likewise belong to this order of plants.

135. **Orobanchaceæ,** BROOM-RAPES. Herbaceous parasitical plants, having scales in place of leaves. Natives of the southern parts of Europe, of Asia, North America, and the Cape of Good Hope. Lindley mentions 12 genera, and 116 species. The properties of these plants are, in general, astringency and bitterness.

136. **Scrophulariaceæ,** FIGWORTS. Herbs, undershrubs, or shrubs, generally distributed over the globe. There are 176 known genera, and 1,814 species. These plants are acrid and slightly bitter, and some are sedative and poisonous. The most important medicinal plant of the order is *Digitalis purpurea*, Foxglove (Fig. 64). Some of the species of *Linaria* and *Calceolaria* are used for dyeing.

137. **Labiatæ,** LABIATES. Herbs or undershrubs, natives chiefly of temperate regions. These plants are in general fragrant or aromatic, and none of them are injurious. Many of them form agreeable condiments, although none are used for ordinary food. Peppermint, Rosemary, Lavender, Marjoram, Mint, Sage, and Thyme, belong to this family. Lindley mentions 125 genera, including 2,350 species.

138. **Verbenaceæ,** VERBENES. Trees, or shrubs, rarely herbs. The order has been divided into three sub-orders:—1, Myoporineæ, natives of South America, Africa, and Australia; 2, Verbenæ, natives of America, tropical and temperate, and found also in Asia and Europe; 3, Selagineæ, natives chiefly of the Cape of Good Hope, and found also in Europe. There are 75 known genera, and upwards of 770 species. Many of the plants are fragrant and aromatic; some are bitter, tonic, and astringent; and others are acrid. The bark of *Avicennia tomentosa* is used in Brazil for tanning. To

this order belongs *Tectona grandis*, the gigantic Teak-tree of India, which attains a height of 200 feet.

139. **Acanthaceæ**, Acanthads. Herbaceous plants or shrubs, abounding in tropical regions. There are, according to Lindley, 105 genera, and about 750 species. These plants have mucilaginous and bitter qualities. The leaves of the Acanthus gave origin to the capital of the Corinthian column.

140. **Lentibulariaceæ**, Butterworts. Aquatic or marsh herbaceous plants, found in all parts of the world. Lindley enumerates 4 genera, and 173 species. These plants have no properties of importance.

141. **Primulaceæ**, Primworts. Herbaceous plants of temperate and cold regions. There are 29 genera, and 215 species. Acridity prevails more or less in these plants. They are chiefly cultivated as showy garden flowers.

142. **Plumbaginaceæ**, Leadworts or Sea-pinks. Herbs or undershrubs, inhabiting the sea shores and salt marshes of temperate regions chiefly. Lindley enumerates 8 genera, and 160 species. Some of the plants are acrid, others have tonic properties.

143. **Plantaginaceæ**, Ribworts. Herbs which are often stemless; they are found chiefly in temperate and cool regions. Lindley notices 3 genera, and 120 species. These plants are frequently bitter and astringent, and their mucilaginous seeds are sometimes used as demulcents.

MONOCHLAMYDEÆ.

Calyx or simple Perianth present; Corolla wanting; Flowers sometimes achlamydeous.

144. **Nyctaginaceæ**, Nyctagos. Herbs, shrubs, or trees, natives principally of warm regions. Lindley mentions 14 genera, and 100 species. Their qualities are mostly purgative. Some species are cultivated as garden flowers.

145. **Amaranthaceæ**, Amaranths. Herbs and shrubs of tropical and temperate regions. There are 38 known genera, and 282 species. These plants are mostly mucilaginous and demulcent. Many of them are cultivated in gardens, including those known under the popular names of Love-lies-bleeding, Cockscomb, &c.

146. **Chenopodiaceæ**, Chenopods. Herbs, under-shrubs, or weeds, found in most parts of the world. There are 67 genera, and 372 species. Many of these plants are used as esculent pot-herbs, as spinage, beet, &c. Beetroot yields a quantity of sugar, and *Ambrina anthelmintica* yields a volatile oil, which is used as a vermifuge.

147. **Phytolaccaceæ**, Phytolaccads. Undershrubs or herbs, natives both of tropical and warm countries. They are found in Asia, Africa, and America. The order has been divided into two sub-orders: 1. Phytolacceæ; 2. Petiverieæ. There are 12 genera, and about 70 species. These plants have frequently acrid qualities, and act as irritant emetics and purgatives. Some yield potash.

148. **Polygonaceæ**, Buckwheats. Herbaceous, rarely shrubby plants, found in most parts of the world, but especially in north temperate regions. The order has been divided into—1. Polygoneæ; 2. Eriogoneæ. These plants have astringent and acrid properties; some are purgative, and a few acrid. The fruit of *Fagopyrum esculentum* (Fig. 65), and other species of Buckwheat, is used as food. One of the most important plants of the order is the Rhubarb plant. Lindley notices 29 genera, and 490 species.

149. **Begoniaceæ**, Begoniads. Semi-succulent herbaceous plants and undershrubs, natives of warm countries. Their leaves and young stems are acrid, the roots are astringent and slightly bitter. *Begonia obliqua* is sometimes called Wild Rhubarb. There are 3 genera, and 159 species.

150. **Lauraceæ**, Laurels. Trees, and sometimes twining parasitic, and leafless herbs, or undershrubs. Natives chiefly of the tropical regions of Asia and America. The order has been divided into two sub-orders: 1. Laureæ, true laurels, trees with leaves; 2. Cassytheæ, Dodder-laurels, climbing parasitic plants without leaves. There are 46 genera, and 450 species. These plants are, in general, aromatic and fragrant; many of them furnish oils, others camphor. some have bitter and tonic barks, and others supply useful timber. *Camphora officinarum* is the camphor tree of China and Japan. *Sassafras officinarum* is an American tree, the root of which is used in medicine. *Cinnamomum zeylanicum* is the true Cinnamon tree of Ceylon. The bark of the tree is the cinnamon of commerce; the root yields camphor. Another species, *Cinnamomum Cassia*, supplies the Cassia bark of commerce. The clove nutmegs of Madagasca are produced by *Agathophyllum aromaticum*; and Brazilian nutmegs by *Cryptocarya moschata*. (Figs. 66, 67, 68.)

151. **Myristicaceæ**, Nutmegs. Trees of the tropical regions of Asia and America. There are 5 genera, and upwards of 30 species. Acridity and aromatic fragrance are the properties of these plants. The most important species is *Myristica officinalis*, a tree of the Moluccas. The fruit is drupaceous, and when ripe opens by two valves,

URTICACEÆ.

Fig. 80.
Hop.

PIPERACEÆ.

Fig. 81.
Black Pepper Plant.

AMENTACEÆ.

Fig. 82.
Willow. 15-4

AMENTACEÆ.

Fig. 83.
Birch.

AMENTACEÆ.

Fig. 84.
Plane.

AMENTACEÆ.

Fig. 85.
Alder.

AMENTACEÆ.

Fig. 86.
Oak.

AMENTACEÆ.

Fig. 87.
Beech.

AMENTACEÆ.

Fig. 88.
Spanish Chestnut.

AMENTACEÆ.

Fig. 89.
POPLAR.

AMENTACEÆ.

Fig. 90.
CORK TREE.

JUGLANDACEÆ.

Fig. 91.
WALNUT.

CONIFERÆ.

Fig. 92.
NORWAY FIR.

CONIFERÆ.

Fig. 93.
SCOTCH FIR.

CONIFERÆ.

Fig. 94.
SILVER FIR.

CONIFERÆ.

Fig. 95.
LARCH.

CONIFERÆ.

Fig. 96.
TAR TREE.

CONIFERÆ.

Fig. 98.
WEYMOUTH PINE.

displaying the beautiful scarlet arillus, which constitutes mace. Within this is a dark-brown shell, covering the kernel, which is the nutmeg of commerce. (Fig. 69.)

152. **Proteaceæ**, PROTEADS. Shrubs or small trees, natives chiefly of Australia and the Cape of Good Hope. Lindley mentions 44 genera, and 650 species. The order has been divided into two sub-orders: 1. Nucumentaceæ; 2. Follicalares. These plants have no medicinal qualities of importance. They present great diversity of appearance, and are cultivated for their beauty and the peculiarity of their flowers.

153. **Elæagnaceæ**, OLEASTERS. Trees or shrubs, found in all parts of the northern hemisphere. Properties unimportant. The fruit of some is eaten, and *Hippophaee rhamnoides* also yields a yellow dye. There are 4 known genera, and 30 species.

154. **Penæaceæ**, SARCOCOLLADS. Shrubs, found at the Cape of Good Hope, with no properties of importance. The gum-resin, Sarcocal, is furnished by some species. 3 known genera, 21 species.

155. **Thymelæaceæ**, DAPHNADS. Shrubby, rarely herbaceous plants. Natives of various parts of the world, both in warm and temperate regions. There are two sections of the order: 1. Daphneæ; 2. Hemandieæ. Lindley mentions 38 genera, and 300 species. The bark of many species is acrid and irritant, the fruit narcotic. The bark of many of the plants is made into ropes and paper.

156. **Aquilariaceæ**, AQUILARIADS. Trees, of the tropical regions of Asia. Some species furnish a fragrant wood called Eagle, or Aloes-wood. There are 6 genera, and 10 species.

157. **Chailletiaceæ**, CHAILLETIADS. Trees or shrubs, of the warm parts of Africa and South America. The fruit of some species is said to be poisonous. There are 4 known genera, and 10 species.

158. **Samydaceæ**, SAMYDS. Trees, natives chiefly of tropical America. Some species of *Casearia* are bitter and astringent. There are 5 known genera, and 80 species.

159. **Homaliaceæ**, HOMALIADS. Trees or shrubs of the tropics. They do not possess any important properties. Lindley mentions 8 genera, including 30 species.

160. **Santalaceæ**, SANDALWOODS. Trees, shrubs, or herbs found in Europe, Asia, America, and Australia. There are 18 genera and 110 species. Some are astringent, others yield fragrant wood. The seeds of some species are eaten, and the large seeds of *Pyrularia oleifera*, Buffalo-tree, or Oil-nut, yield oil.

161. **Aristolochiaceæ**, BIRTHWORTS. Herbs or shrubs, often climbing, found in abundance in the warm regions of South America, and found also in temperate and cold regions of other parts of the world. These plants are generally bitter, tonic, and stimulant, while some are acrid. The snake-roots of Canada and Virginia belong to plants of this order. There are 8 known genera and 130 species.

162. **Nepenthaceæ**, PITCHER-PLANTS. Herbs or half-shrubby plants, natives of swampy parts in the East Indies and China. They have no known properties. Lindley mentions 1 genus and 6 species.

163. **Datiscaceæ**, DATISCADS. Herbaceous branched plants or trees, scattered over North America, parts of Asia, and the south-east of Europe. Some of the plants are bitter, and others purgative. Lindley mentions 3 genera, and 4 species.

164. **Empetraceæ**, CROWBERRIES. Heath-like shrubs of Europe and North America, chiefly. They have slightly acid properties. 4 genera, and 4 species.

165. **Euphorbiaceæ**, SPURGE-WORTS. Trees, shrubs, or herbs, often having acrid milk. These plants abound in warm regions, especially in tropical America, where they are found as trees or bushes, or lactescent herbs, often presenting the appearance of Cactuses. They are also found in North America and Europe. In Britain there are 18 species. There are in all 192 known genera, and upwards of 2,500 species. These plants are acrid and poisonous. In many cases, the elaborated sap contains caoutchouc and resin. The seeds of many species yield oils, some of a bland, and others of an irritating, nature. Castor-oil is expressed from the seeds of *Recinus communis.* Croton-oil is obtained from the seeds of *Croton Tiglium*, an Indian shrub. Cascarilla is the bark of *Croton Eleuteria*, and other species. The Box-tree, *Buxus sempervirens*, whose wood is used for wood-engraving, belongs to this family—as does the Cassava, or Manioc plant, the starch of which is used in the form of bread. From the starch of the Bitter Cassava, Tapioca is prepared. The milky sap of *Siphonia elastica* furnishes the bottle India-rubber. *Aleurites laccifera* supplies gum-lac; and *Crozophora tinctoria*, a purple dye called Turnsole. (Figs. 70, 71, 72.)

166. **Urticaceæ**, NETTLEWORTS. Herbs, shrubs, or trees. The order has been divided into five sub-orders:—1. Urticeæ, True Nettles; 2. Cannabinæ, Hemp tribe; 3. Ulmaceæ, Elm tribe; 4. Moreæ, Mulberry tribe; 5. Artocarpeæ, Bread-fruit tribe. These plants are widely scattered, most of them are found in temperate climates; the Mulberry tribe in temperate and warm regions, and the Bread-fruit tribe within the tropics. The properties of the order are various. Many yield valuable fibres, others

edible fruits, others supply caoutchouc, and some form important forest trees. *Cannabis sativa* furnishes the valuable fibre, Hemp. *Humulus Lupulus* supplies the Hop. Several species of Elm are cultivated for timber. The common Fig is the fruit of *Ficus Carica;* and many other species of *Ficus* yield edible fruits. The plants of the Fig tribe are remarkable for the adventitious roots which they send out from the stems. *Ficus indica,* the Banyan tree, is celebrated in this respect. *Ficus elastica* is an Indian tree which yields a large quantity of caoutchouc, as do also some other species of *Ficus. Morus alba* is the White Mulberry, the leaves of which are the favourite fruit of silk-worms. *Broussonetia papyrifera* is the *Paper Mulberry,* which is used in China and Japan for making a kind of paper. The dye-wood called Fustic is produced by *Maclura (Broussonetia) tinctoria. Artocarpus incisa,* the Bread-fruit tree, supplies an amylaceous fruit which affords an abundant supply of food in tropical countries. This important order comprises between 60 and 70 known genera, and about 600 species. (Figs. 73 to 80.)

167. **Ceratophyllaceæ,** HORNWORTS. Aquatic herbs, found in ditches. 1 genus, and 6 species. Properties unimportant.

168. **Podostemaceæ,** PODOSTEMADS. Herbaceous floating plants, of South America and some African islands. Little is known of their properties. Lindley gives 9 genera, and 25 species.

169. **Stilaginaceæ,** ANTIDESMADS. Trees or shrubs, of the East Indies. Some furnish edible fruits. There are 3 genera, and 20 species.

170. **Monimiaceæ,** MONIMIADS. Trees or shrubs, of South America and Australia. They are fragrant and aromatic, and some yield edible fruit. 8 genera, and 40 species.

171. **Atherospermaceæ,** PLUME NUTMEGS. Trees, of Australia and parts of South America. Mostly fragrant. There are 3 genera, and 4 species.

172. **Lacistemaceæ,** LACISTEMADS. Shrubs or small trees, found in the warm parts of America. Properties unknown. There are 2 genera, and 6 species.

173. **Chloranthaceæ,** CHLORANTHS. Herbs or undershrubs, of the warm parts of India and America. Some are fragrant and aromatic. 3 genera, and 15 species.

174. **Saururaceæ,** SAURURADS. Marsh herbs, of North America, India, and China. They have acrid properties. There are 4 genera, and 7 species.

175. **Piperaceæ,** PEPPER-WORTS. Shrubs or herbs, natives of the hottest regions of the globe. These plants are pungent, acrid, and aromatic; some are narcotic. Most of them contain an acrid resin and a crystalline matter, called Piperin. The Black-pepper plant (Fig 81) is a climbing species common in the East Indies. There are 21 known genera, and upwards of 600 species.

176. **Amentaceæ,** CATKIN-BEARING TRIBE. Trees or shrubs, chiefly natives of temperate regions. The order has been divided into seven sub-orders, as follows: 1. Salicineæ, the Willow Tribe, found in temperate and cold regions; 2. Myriceæ, the Gule Tribe, found in North and South America, India, and at the Cape of Good Hope. 3. Casuarineæ, the Beef-wood Tribe, Australian trees and shrubs; 4. Betulineæ, the Birch tribe, natives of temperate and cold regions; 5. Balsamaceæ, the Liquidambar tribe, balsamic trees of warm regions; 6. Plataneæ, the Plane tribe, trees of temperate climates; 7. Cupiliferæ, the Nut tribe, natives of temperate regions chiefly. This extensive Amental alliance embraces 18 genera, and 600 species. Some of its plants yield resinous and balsamic fluids, and the seeds of others are used for food. Among the timber trees of this order may be mentioned the Birch, Alder, Plane, Hazel, Oak, Beech, Spanish Chesnut, Poplar, and the Willow. The specie sof *Myrica* are aromatic, and yield resinous and oily matter. *Myricia cerifera,* or Wax Myrtle, yields a greenish wax, used for candles. A resinous matter, known as Liquid Storax, is obtained from various species of *Liquidambar;* and from the bark of the common Birch is obtained an oil which gives the peculiar odour to Russian leather. (Figs. 82 to 90)

177. **Juglandaceæ,** WALNUTS. Trees, natives chiefly of North America. There are 4 genera, and 27 species. These plants yield oily nuts, and the seeds of the common Walnut supply a bland oil. The trees furnish a valuable timber, which is hard, and susceptible of a high polish. (Fig. 91.)

178. **Garryaceæ,** GARRYADS. Shrubs of North America, remarkable for their peculiar silky catkins. 2 genera, and 6 species.

179. **Coniferæ,** CONE-BEARING TRIBE. Trees or shrubs, of both hot and cold regions. Some of the genera are peculiar to the Southern hemisphere. This extensive order has been divided into four sub-orders, as follow:—1. Abietineæ, the Fir and Spruce tribe; 2. Cupressineæ, the Cypress tribe; 3. Taxineæ, the Yew tribe; 4. Gnetaceæ, the Joint-Fir tribe. The order comprises 31 genera, and about 165 species. These plants furnish valuable timber, and yield various important products, as turpentine, pitch, and resin. The various kinds of Pine, Fir, Spruce, and Cedar, belong to this family. Turpentine is obtained from the Scotch Fir, and different species of Pine. Pitch is yielded by the Norway Spruce Fir. Balsam is procured from different

CONIFERÆ.

Fig. 99.
STONE PINE.

CONIFERÆ.

Fig. 97.
WELLINGTONIA GIGANTEA.
The Mammoth Tree of California.
Height 363 *ft., diameter* 31 *ft.*
Supposed age 3000 *years.*

CONIFERÆ.

Fig. 100.
YEW.

CONIFERÆ.

Fig. 101.
CEDAR.

CONIFERÆ.

Fig. 102.
CYPRESS.

CYCADACEÆ.

Fig. 103.
CYCAS.

DIOSCOREACEÆ.

Fig. 104.
YAM PLANT.

ORCHIDACEÆ.

Fig. 105.
ORCHID.

ZINGIBERACEÆ.

Fig. 106.
GINGER PLANT.

ZINGIBERACEÆ.

Fig. 107.
TURMERIC.

MARANTACEÆ.

Fig. 108.
ARROW-ROOT.

MUSACEÆ.

Fig. 109.
BANANA.

AMARYLIDACEÆ.

Fig. 110.
AGAVE.

BROMELIACEÆ.

Fig. 111.
PINE-APPLE.

BROMELIACEÆ.

Fig. 112.
MANY-HEADED PINE.

LILIACEÆ.

Fig. 113.
ALOES PLANT.

LILIACEÆ.

Fig. 114.
DRAGON'S-BLOOD TREE.

species of Fir and Pine. To this order belongs Wellingtonia gigantea, the Mammoth tree of California, 363 feet in height (about that of St. Paul's Cathedral, London), and having a diameter of 31 feet. A portion of the bark of one of these trees is placed round a framework at the Crystal Palace, Sydenham, showing the enormous size of this giant of the vegetable kingdom. (Figs. 92 to 102.)

180. **Cycadaceæ**, CYCADS. Trees or shrubs, in some respects resembling the Palms, and in others the Ferns. These plants are found in the warm and temperate parts of America and Asia, and at the Cape of Good Hope. There are 6 genera and 45 species. These plants yield starch and mucilaginous matter, the latter hardening into a transparent gum. Some species furnish sago and a kind of arrow-root. (Fig. 103.)

ENDOGENS.

This great class of plants is distinguished by the following physiological peculiarities:—1. The wood is endogenous—that is, increases by the addition of new woody matter in the *centre* of the trunk. 2. The leaves are straight-veined (except in the sub-class, Dictyogenæ), and are not jointed to the stem; consequently, do not readily fall off when dead. 3. The organs of fructification are ternary. 4. The seeds have only one cotyledon or seed-lobe.

DICTYOGENÆ.

Leaves reticulated. Rhizomes mostly circular.

181. **Dioscoreaceæ**, YAMS. Twining shrubs, with large tubers, natives of tropical regions. There are 6 genera, and 110 species. Acridity prevails in these plants, although a farinaceous matter is found in the tubers of some species. The latter, called Yams, are used in warm countries as a substitute for the potato. (Fig. 104.)

182. **Smilaceæ**, SARSAPARILLAS. Herbs or under-shrubs, often climbing. Found in the temperate and tropical parts of Asia and America. There are 4 or 5 genera, and about 120 species. These plants possess mucilaginous and demulcent properties. The various species of *Smilax* furnish the sarsaparilla, which is used as a tonic and alterative.

183. **Trilliaceæ**, PARIDS. Herbaceous plants, with tubers or rhizomes. Natives of the temperate parts of Europe, Asia, and America. Some are narcotic, others more or less acrid, and some emetic. Lindley mentions 4 genera, and 30 species.

PETALOIDEÆ.

Flowers having usually a Perianth of verticillate leaves, or of a few whorled scales. Occasionally the Perianth is abortive.

184. **Hydrocharidaceæ**, HYDROCHARADS. Floating or aquatic plants, found chiefly in Europe, Asia, and North America. Their properties are not important; some are mucilaginous and astringent. There are 12 genera, and 20 species.

185. **Orchidaceæ**, ORCHIDS. Perennial herbs or shrubs, with showy flowers, found in most parts of the world, and abounding in moist tropical regions. Lindley enumerates 396 genera, and about 3,000 species. Some of these plants are fragrant and aromatic, others are mucilaginous. (Fig. 105.)

186 **Zingiberaceæ**, GINGER WORTS. Tropical herbs, with a creeping rhizome and frequently showy flowers. Their rhizomes and seeds have aromatic stimulant properties, and some species yield starch. The rhizome of *Zingiber officinale* constitutes the Ginger of commerce. *Curcuma longa* furnishes Turmeric. *Amomum*, *Elettaria*, and some other species, furnish Cardamoms and Grains of Paradise. *Curcuma augustifolia* supplies East Indian Arrow-root. There are 29 genera and 247 species. (Figs. 106, 107.)

187. **Marantaceæ**, MARANTS. Herbaceous plants, with tuberous rhizomes, similar to the Ginger Family, and natives likewise of the tropics. Lindley mentions 6 genera, and 160 species. These plants contain starch in the rhizomes and roots. Arrow-root is supplied by the tuberous rhizome of *Maranta arundinaceæ* and *M. indica*, as well as some other species. (See Fig. 108.)

188. **Musaceæ**, MUSADS, or BANANAS. Stemless or nearly stemless plants, with leaves sheathing at the base, and forming a kind of spurious stem. Natives of warm and tropical regions. These plants furnish a large supply of nutritious fruit, and their leaves yield valuable fibres. It is said that the same extent of ground which in wheat would only maintain two persons will yield sustenance, under the Banana, to fifty. Manilla Hemp is the produce of *Musa textilis*. 5 genera and 21 species. (Fig. 109.)

189. **Iridaceæ**, IRIDS. Herbaceous plants, with rhizomes, or under-ground corms. Natives chiefly of warm and temperate regions, and abounding at the Cape of Good Hope. There are 53 genera, and 550 species. Some species are fragrant and stimulant, others acrid, and some yield dyes. The rhizome of *Iris Florentina* furnishes Orris-root. *Crocus sativus* supplies the dye Saffron, which is also obtained from some other species.

190. **Burmanniaceæ**, BURMANNIADS. Tropical herbs, found in moist, grassy places. Their properties are unimportant. There are 10 genera, and 35 species.

191. **Hæmodoraceæ**, BLOOD-ROOTS. Herbaceous plants, with fibrous roots. Found

in various warm parts of the world. Lindley mentions 13 genera, and 50 species. The roots of these plants supply a red dye.

192. **Amaryllidaceæ**, Amaryllids. Generally bulbous plants, sometimes with fibrous roots. Natives chiefly of the Cape of Good Hope. Lindley notices 68 genera, and 400 species, and he divides them into four sub-orders:—1. Amaryllceæ, bulbs without a coronet in the flower. 2. Narcisseæ, bulbs, with a coronet. 3. Alströmerieæ, fibrous rooted, sepals different in form from the petals. 4. Agaveæ, fibrous rooted, sepals and petals alike. The bulbs of many of these plants are poisonous; some are emetic, and others yield a spirit, The tough fibres of some species, as the American Aloe (Fig. 110), are used for flax. The juice of this plant yields also an intoxicating drink.

193. **Hypoxidaceæ**, Hypoxids. Herbaceous and frequently stemless plants, with tuberous and fibrous roots. Natives of warm countries. Some have bitter roots, others have edible tubers. Lindley mentions 4 genera, and 60 species.

194. **Bromeliaceæ**, Bromel-worts or Pine-apples. Stemless or short-stemmed plants of the warm parts of America chiefly. These plants are more or less epiphytic, that is, are able to grow without any direct attachment to the soil. The fruit of Ananassa is the Pine-apple or Ananus, well known for its sweetness and fine flavour. In its wild state, however, it is excessively acid (Figs 111 and 112). There are 23 genera, and 170 species.

195. **Liliaceæ**, Lily-worts. Herbaceous plants, shrubs, or trees, with bulbs, tubers, rhizomes or fibrous roots. They are found both in temperate and tropical countries. There are, according to Lindley, 133 genera, and 1,200 species. He divides the order into twelve sub-orders, as follows:—1. Tulipeæ, Tulip tribe; 2. Hermerocallideæ, or Day-lily tribe; 3. Aloineæ, or Aloes; 4. Scilleæ, or Squills; 5. Conanthereæ; 6. Anthericeæ; 7. Aphyllantheæ; 8. Wachendorffeæ; 9. Asparageæ; 10. Aspidistreæ; 11. Ophiopogoneæ; 12. Convallarieæ. Many of these plants are showy garden flowers, as Tulips, Lilies, &c.; others are used medicinally, as Squill, Aloes, &c. Some yield valuable fibres, as *Phormium tenax*, New Zealand Flax. *Drucæna Daruco*, and other species, supply a resinous matter called Dragon's-blood. *Xanthorræa hastilis*, the Grass-tree of Australia, which gives a peculiar feature to the vegetation of that region, yields a yellow gum. The base of the inner leaves of some Grass-trees is also used as food. (Figs. 113, 114, and 115).

196. **Melanthaceæ**, Melanths, or Colchicums. Bulbous, tuberous, or fibrous-rooted plants, extremely variable in appearance. Found in various parts of the world, but most abundant in northern countries. There are 30 known genera, and 130 species. These plants are mostly poisonous; some, however, have valuable medicinal qualities, and are employed in the cure of gout and rheumatism.

197. **Gilliesiaceæ**, Gilliesiads. Herbaceous plants, with bulbs. Natives of Chili. Their properties are unknown. There are 2 genera, and 5 species.

198. **Pontederiaceæ**, Pontederads. Aquatic or marsh plants, without important properties. They are found in America, the East Indies, and Africa. 6 genera, and 30 species.

199. **Xyridaceæ**, Xyrids. Herbaceous, sedgy plants, with fibrous roots. Natives chiefly of tropical countries, and without important properties. 6 genera, and 70 species.

200. **Juncaceæ**, Rushes. Herbaceous plants, of the colder regions of the globe. Many species are used in the manufacture of mats, bottoms of chairs, &c. There are 14 genera, and 200 species.

201. **Palmæ**, Palms. Arborescent plants, with simple, rarely-branched trunks, marked with the scars of the leaves. Natives of the tropics chiefly, and imparting to them much of their botanical physiognomy. "The race of plants to which the name of Palms has been assigned is, no doubt," says Dr. Lindley, "the most interesting in the vegetable kingdom, if we consider the majestic aspect of their towering stems, crowned by a still more gigantic foliage; the character of grandeur which they impress upon the landscape of the countries they inhabit, their immense value to mankind, as affording food and raiment, and numerous objects of economical importance; or, finally, the prodigious development of those organs by which their race is to be propagated." There are 73 known genera, and 400 species, but the numbers are probably much greater. They have been divided into the following tribes:—1. Arecineæ, the Betel-nut tribe; 2. Lepidocaryinæ, the Sago tribe; 3 Borassinæ, the Palmyra tribe; 4. Coryphinæ, the Talipot and Date tribe; 5. Coccinæ, the Cocoa-nut tribe. The properties of these plants are very various. In the countries where they grow they supply food, and are used for forming habitations. Many supply oil, wax, starchy matter, and sugar, which, fermented, forms an intoxicating beverage. Their fibres also furnish materials for ropes, cordage, and weaving. Some species of *Calamus* furnish canes more than 500 feet in length, which are used as cables. *Phytelephas macrccarpa*, the Ivory Palm, supplies a hard white substance called Vegetable

LILIACEÆ.

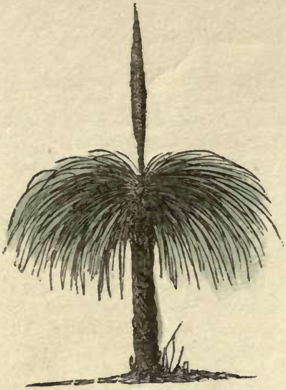


Fig. 115.
AUSTRALIAN GRASS TREE.

PALMÆ.

Fig. 116.
COCOA-NUT PALM.

PALMÆ.

Fig. 117.
DATE PALM.

PALMÆ.

Fig. 118.
WAX PALM.

PALMÆ.

Fig. 119.
OIL PALM.

PALMÆ.

Fig. 120.
SAGO PALM.

PALMÆ.

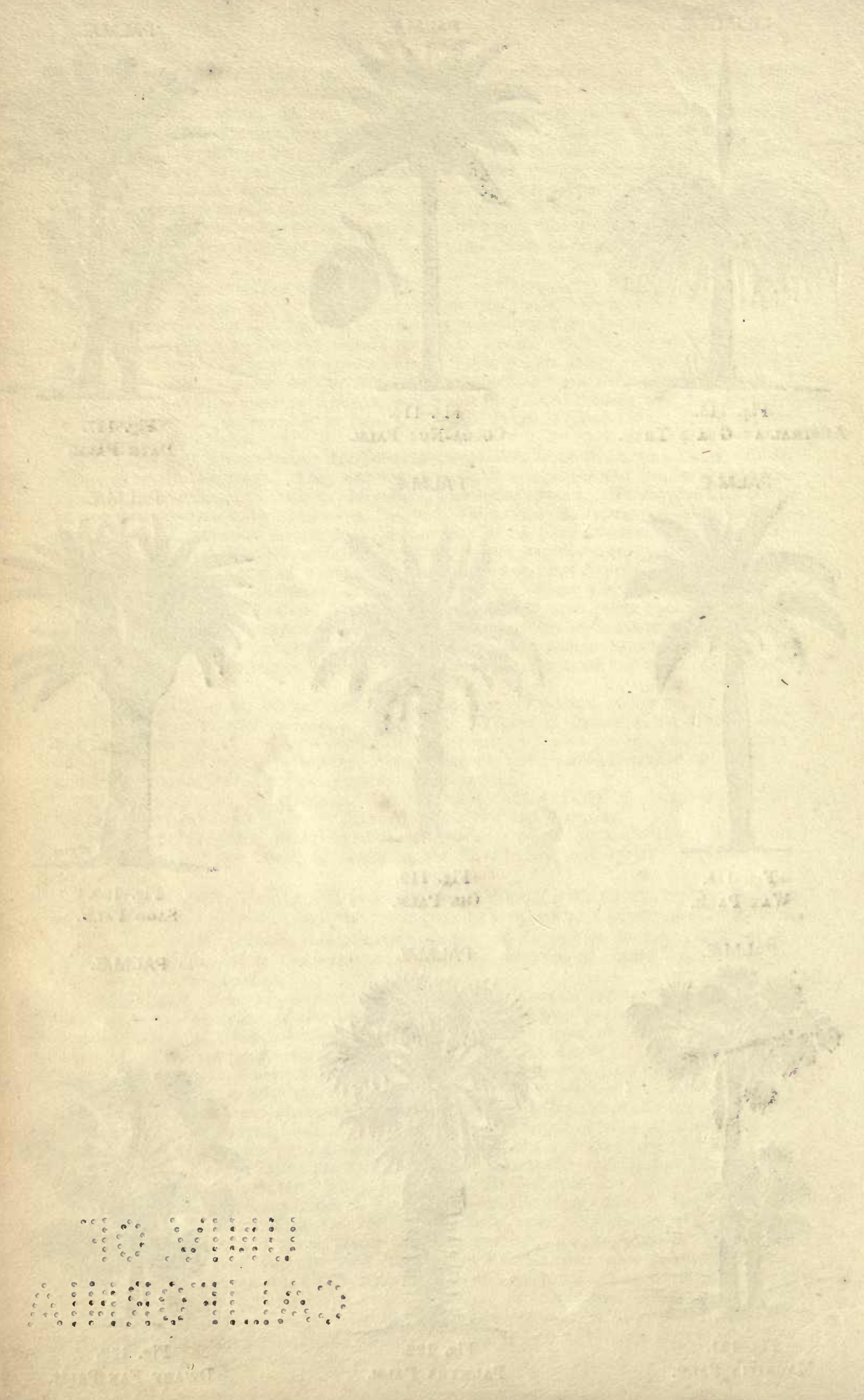
Fig. 121.
MAURITIA PALM.

PALMÆ.

Fig. 122.
PALMYRA PALM.

PALMÆ.

Fig. 123.
DWARF FAN PALM.



PALMÆ.

Fig. 124.
IVORY PALM.

PALMÆ.

Fig. 125.
DOOM PALM.

PANDANACEÆ.

Fig. 126.
SCREW PINE.

ARACEÆ.

Fig. 127.
ARUM.

GRAMINEÆ.

Fig. 128.
WHEAT AND BARLEY.

GRAMINEÆ.

Fig. 129.
OATS.

GRAMINEÆ.

Fig. 130.
RYE AND MILLET.

GRAMINEÆ:

Fig. 131.
RICE.

GRAMINEÆ.

Fig. 132.
MAIZE, OR INDIAN CORN.

Ivory. The *Date Palm* furnishes food to the tribes of the Desert, and the *Doom Palm* of Egypt is called the Gingerbread Tree, from the resemblance of its mealy rind to that article. Palm oil is obtained chiefly from *Elais guineensis*, and *melanococca*, and these trees are also said to yield the best Palm wine. The *Ceroxylon andicola*, or Wax Palm of Humboldt, has its trunk covered with a coating of wax, which exudes from the spaces between the insertion of the leaves. (See Figs. 116 to 125.)

202. **Commelynaceæ**, Spider-worts. Herbaceous plants of warm climates. Some have fleshy rhizomes, containing a starchy matter, which is used for food. There are 17 genera, and 264 species.

203. **Alismaceæ**, Alismads. Aquatic plants, natives both of tropical and temperate climates. Their properties are unimportant. There are 5 genera and about 70 species.

204. **Butomaceæ**, Butomads, or Flowering-Rushes. Aquatic plants, often lactescent. Found chiefly in marshes of northern countries. Some of them have bitter and acrid properties. Lindley mentions 4 genera, and 7 species.

205. **Pandanaceæ**, Screw-Pines. Trees or bushes, sometimes sending down aerial roots. Natives of tropical regions, and common in the islands of the Indian Archipelago. There are 7 genera and 75 species. Their flowers are generally fragrant, and their seeds are used as food. The roots of these remarkable trees are sent down from all parts of their stems, and appear like artificial props. (Fig. 126.)

206. **Araceæ**, Arums. Herbaceous or shrubby plants, sometimes with tubers or creeping rhizomes. They occur in various parts of the world, abounding in the tropics. These plants have been arranged in four orders, as follows:—1. Arineæ, Cuckoo-pint tribe. 2. Typhineæ, Bulrush tribe. 3. Acoreæ, Sweet-flag tribe. 4. Pistieæ, Duckweed tribe. The order includes 47 genera and 273 species. Their general property is acridity, and some of the plants are dangerous poisons. The rhizomes of some species yield starchy matter, and when boiled or roasted are used as food. Some of these plants send out aerial roots, by means of which they climb upon trees. (Fig. 127.)

207. **Naiadaceæ**, Naiads, or Pondweeds. Water plants of both the ocean and fresh water. They are found in various parts of the world, but have no properties of importance. There are 19 known genera, and upwards of 70 species.

208. **Restiaceæ**, Restiads, or Cord-rushes. Herbaceous plants or under-shrubs. They are found chiefly in America and Australia, and are without important properties. The tough, wiry stems of some species are used for making baskets and brooms. There are 36 genera, and 286 species.

209. **Cyperaceæ**, Sedges. Grass-like herbs growing in tufts, with solid stems, sometimes creeping, often angular, and without joints. They are found in all quarters of the globe, and at all elevations; many species occur in marshy ground. Lindley mentions 112 genera, and 2,000 species. This order includes the Papyrus of the Nile, the plant anciently used in the manufacture of paper. Some species of *Cyperus* have tubers which are used as food, and the roots of others have been employed as bitter tonics. The stems of some are used for chair bottoms.

210. **Gramineæ**, Grasses. Herbaceous plants, with cylindrical, hollow, and jointed stems, called culms. The grasses are found in all parts of the world, and are said to form about one twenty-second part of all known plants. In tropical regions they frequently occur as trees. Lindley enumerates 291 genera, including about 3,800 species. To the section of grasses supplying food for man belong the nutritious cereal grains, as Wheat, Oats, Barley, Rye, Rice, Maize, Millet, &c. Sugar is also obtained from many grasses, known as sugar canes. To the herbage grasses, affording food for animals, belong the various pasture grasses, as Rye grass, Meadow grass, &c. In the warmer parts of the world, the fodder grasses attain the height of five or six feet, but are yet sufficiently tender to be used as animal food. (Figs. 128 to 133.)

211. **Rhizantheæ**, Rhizanths, or Rhizogens. Leafless, scaly, parasitic plants, having a fungus-like appearance, and of a brown yellow or purple colour. These plants are frequently stemless, but have sometimes a creeping rhizome. They are found chiefly in tropical climates, and are employed as styptics. There are 21 genera, and 53 species. To this order belong the species of *Rafflesia*, gigantic parasites, the perianth of which is frequently three feet in diameter. (Fig. 134).

CRYPTOGAMOUS, OR CELLULAR FLOWERLESS PLANTS.

ACROGENS.

The most simple form of plants; their structure mostly entirely cellular; their propagation effected by means of spores.

ACROGENÆ.

Having usually distinct stems, leaves, stomata, some vascular tissue, and thecæ or spore cases.

212. **Equisetaceæ**, Horse-tails. Leafless branched plants, with a striated fistular

stem, in the cuticle of which silex is secreted. Found in rivers, ditches, &c., in various parts of the world. They are sometimes used for polishing furniture, &c. Lindley mentions 1 genus, and 10 species. (Fig. 135.)

213. **Filices**, Ferns. Elegant leafy plants, occurring chiefly in moist, insular climates, and abounding in the tropical islands. In warm countries they occur as Tree-ferns, fifty or sixty feet in height. The properties of the Ferns are in general demulcent and astringent. The rhizomes of some are used as food, and others supply tanning material. The syrup called Capillaire is prepared from some species. Lindley notices 192 genera, and upwards of 2,000 species. (Fig. 136).

214. **Marsileaceæ**, Pepper-worts. Stemless plants, creeping or floating, found in ditches and pools. They are not put to any important use. There are 4 genera, and upwards of 20 species.

215. **Lycopodiaceæ**, Club-mosses. Moss-like plants, with creeping stems, and imbricated leaves, intermediate between Ferns and Mosses. They abound in moist, warm, insular climates. These plants have, in their spore cases, an inflammable powder, called vegetable brimstone, which is employed on the Continent in the manufacture of fire-works, and in pharmacy to roll up pills to render them impervious to damp. There are 6 genera, and 200 species. (Fig. 137).

216. **Musci**, Mosses. Erect, creeping, terrestrial, or aquatic plants, found in all moist regions, and abounding in temperate climates. There are, according to Lindley, 46 known genera, and 1,100 species.

217. **Hepaticæ**, Liverworts. Plants growing on the earth or trees in damp places. They are generally distributed over the globe, both in cold and warm climates. There are 65 genera, and about 700 species.

THALOGENÆ, or CELLULARES.

Structure entirely cellular, without distinct stems, leaves, or stomata.

218. **Lichenes**, Lichens. Plants often spreading over the surface of the earth, or rocks, or trees, in dry places, as a foliaceous, hard, or leprous substance, called a thallus. They are found in all parts of the world, and seem to derive their nourishment principally from the atmosphere. Lichens furnish articles of food and important dyes; among the former class is the substance known as Iceland Moss. *Cladonia rangiferina* is a Lichen upon which the Reindeer feeds. The valuable dyes, Orchil, Cudbear, and Parietin, are obtained from different species of Lichens (Fig. 138). Lindley gives 58 genera, and 2,400 species.

219. **Fungi**, Mushrooms. Cellular plants, variable in their consistence, soft or hard, fibrous or gelatinous, fleshy or leathery. Found in all parts of the world. There are, according to Berkeley, 598 genera, and 4,000 species. Some species are edible, as the common Mushroom, Morel, and Truffle; others are poisonous; and some very destructive, from their parasitical growth. Some Fungi are limited to certain kinds of decaying matter; thus peculiar species are developed in vinegar, yeast, flour, &c. The rapidity of their growth is also remarkable. Blight, mildew, rust, and smut, are diseases in grain due to the attacks of Fungi, as is also dry-rot in timber. (Fig. 139.)

220. **Algæ**, Sea-weeds. Cellular plants found in salt and fresh water, and in moist places, as on damp rocks, the glass and pots of hothouses, and in hot springs. These plants have been arranged into five divisions, as follows:—1. Characeæ, water plants formed of parallel tubes, sometimes encrusted with carbonate of lime. 2. Fucaceæ, the Sea-wrack tribe, usually growing in salt water. 3. Florideæ, rose or purple-coloured sea-weeds, with fronds. 4. Confervaceæ, aquatic plants, consisting of one or more cells united so as to form an articulated or flat frond. 5. Diatomaceæ, crystalline, angular, fragmentary, and brittle fronds, united by a gelatinous substance. Found in still waters and moist places. Lindley enumerates 283 genera, and 2,000 species. Some of the species are very gigantic, others exceedingly minute, requiring a microscope for their detection. The lowest members of the order approach so nearly the lowest tribes of animals, that it is difficult to draw a line of demarcation. Some species are said to occur in red and green snow, and the red and green colours of certain lakes and seas are attributed to these plants. A quantity of gelatinous matter is obtained from these plants, and some of them are used for food, as Carrajeen or Irish Moss (Fig. 140), Dulse, Tangle, Laver, &c. Kelp is obtained by the burning of Sea-weeds, and Iodine is also procured from them.

LAWS OF MATTER & MOTION

LAWS OF MATTER AND MOTION.

As no branch of science can be understood without some previous knowledge of the general properties of matter, it will be desirable to commence by shortly describing them :—

Extension is the bulk of a body, its length, breadth, and thickness.

Impenetrability is that property by which two bodies cannot at the same time occupy one and the same place. If a nail be driven into a block of wood it displaces the particles, but does not become incorporated with them (fig. 1). If in a full glass of water a stone be placed, the water will be forced over to make way for the stone (fig. 2). If we endeavour to fill a phial by plunging it into water, the air will rush out of the phial to make way for the water (fig. 3).

Divisibility denotes the property by which a body is susceptible of being subdivided into an indefinite number of parts. Animalculæ have been found so small that a grain of sand will cover 300,000 of them, each one having a perfect organization ; fig. 4 represents the forms of some highly magnified.

Porosity arises from the influence which heat exercises in separating the particles of matter. The piece of iron B, fig. 6, when cold, will exactly fit into the hole and notch of A ; but if heated it will do neither. Fig. 7 represents the action of heat in expanding and setting in motion the particles of water.

Inertia or **Persistence** is the tendency of matter to preserve its present state, whether of rest or motion, unchanged. Fig. 8 illustrates the first : if the card be struck away the coin will remain balanced on the finger : fig. 9 illustrates the second : a body in motion has a tendency to proceed in a straight line ; but the hare being pursued by a dog, turns quickly, and the latter is irresistibly thrown out of its track and compelled to take a wider turn, thus affording the hare the only chance of escape.

Cohesion is the force by which the atoms of a body are held together in one solid mass. It is greater in some bodies than in others, the solidity or weight of the body corresponding to the cohesive attraction. It is this power which holds the drop of water suspended at the end of the finger, and keeps its minute watery particles united (fig. 10). **Capillary attraction** is another effect of this power which enables liquids to rise above their level in minute tubes (fig .11) Sap ascends in plants by the same force (fig. 12).

Gravitation is that force which causes all bodies on or near the earth to tend towards its centre with a force proportioned to their respective quantities of matter (fig. 13). All bodies attract each other inversely as the squares of the distances. All influences emanating from a central point follow the same law. Fig. 14 illustrates the law in reference to light. At a certain distance the rays illuminate the space A B ; at twice that distance they are spread over C D. four times the former space, but with four times less intensity ; at three times the distance they illuminate the space E F with nine times less intensity, and so on. All bodies possess gravity or weight ; there is no such thing as perfect lightness. Smoke ascends only because it is lighter than the atmosphere (fig. 15). The force of gravity at the surface of the earth is such that in the first second of time, it gives to a body allowed to fall, a volocity of 16 feet ; in the next second 48 feet ; in the third second 80 feet. Fig. 16 shows the rate at which bodies fall ; each of the triangular portions representing 16 feet, the figures on the right, the seconds.

THE CENTRE OF GRAVITY.

The centre of gravity in a body is that about which all its other parts equally balance each other. Figs. 17 to 21 show the position of the centre of gravity in bodies of different forms. The stability of a body resting on the ground depends greatly upon the centre of gravity. The body will stand provided a vertical line drawn from the centre of gravity falls within the base (figs. 22, 24). The mass of rock (fig. 23) will fall because the vertical line falls beyond the base. Bodies having a narrow base are easily upset, for if they are the least inclined their centre is no longer supported, as seen in fig. 25. Rope dancers are provided with a pole, loaded at the ends, for the purpose of bringing their centre of gravity vertically over the rope (fig. 26).

THE PENDULUM.

This body, represented at fig. 27, depends for its motion upon the forces of gravitation and persistence. The longer the pendulum the slower are its vibrations, and. as the length is affected by temperature, various contrivances have been resorted to to correct this expansion and contraction; these are termed *compensation pendulums* (figs. 28, 29). Fig. 30 represents the balance wheel of a watch, with a spring, which is expanded or contracted by the lever C, producing a corresponding effect on the movement of the watch.

CENTRAL FORCES.

These are of two kinds, *centripetal*, or the force of gravity, tending towards the centre; and *centrifugal*, flying from it. The first may be illustrated by a whirlpool at sea, or a whirlwind on land (figs. 31 and 32). Centrifugal force may be illustrated in a variety of ways. If we whirl rapidly a sling with a stone in it, and suddenly set free the stone, it will proceed in a straight line (fig. 33). In turning rapidly a circular grindstone in contact with water, the latter will fly off at right angles (fig. 34). A practical application of this power is seen in the governor-balls of a steam engine (fig. 35). By any increase in the velocity in the engine, the balls are thrown apart, and the levers draw down the collar, D, and with it the end of the lever, F, which thus partially closes the throttle-valve of the steam pipe.

The centripetal and centrifugal forces are sublimely exemplified in the motions of the planetary bodies; the former in their attraction towards the central luminary by gravitation; and the latter in their tendency to proceed in a straight line by the force of persistence.

The velocity of revolving bodies increases in proportion to the distance from the centre of motion. The extremities of the vanes of the windmill move over a much greater space than the parts near the axis, yet describe the circle in the same space of time (fig. 36). In like manner, as our globe turns on its axis, those parts nearer the poles describe smaller circles than those more remote; the equatorial regions describing the largest circles of all, hence, it follows, that the equatorial regions move at a far greater velocity than the regions near the poles (fig. 37).

LAWS OF MOTION.

A body projected by a single force naturally proceeds in the direction of that force; but if in its progress a new force acts upon it, it will then be sent in a new direction. Thus, a ball projected in the line A B C (fig. 38), strikes obliquely the ledge at C, there meeting an obstacle to its progress, which acts as a new force, it is caused to rebound in the direction C D E, making the same angle with the ledge as did the original path of the ball A B C. This effect is commonly expressed by saying that the angle of *incidence* is equal to the angle of *reflection*, the former meaning the angle A B C, and the latter C D E; and this is a law that applies equally to the motions of sound, heat, and light; and therefore, is of the utmost importance throughout physics. If two or more forces act upon a body at certain angles, a single force may be found which would produce the same effect. This single force is called the *resultant* or *equivalent*. In fig. 39 we have an example of this: a ball receiving a blow in the direction A B, and at the same time a blow of equal force in the direction A D, does not pursue either of those directions, but takes a diagonal course between them to C. The effect being the same as if the ball had been sent in the direction A C, by a single force.

The process of finding a single force equivalent to two or more forces is called the *composition of forces*, and the process of finding forces which will produce a motion equal to that of a single force, is called the *resolution of forces*. In fig. 40, this is illustrated in reference to the action of the wind upon the sail of a ship, and of the tide upon the helm. Let A B represent the direction of the wind acting upon the sail E F, placed obliquely to it, then, by drawing A C perpendicular to F E, and by completing the parallellogram D C; the diagonal A B is resolvable into the adjacent sides A C and A D; now, A C being at right angles to E F, will have the effect of propelling the vessel, although not in a straight line; but it may be guided in the desired direction by means of the helm, upon which the water re-acts by the progressive motion of the vessel

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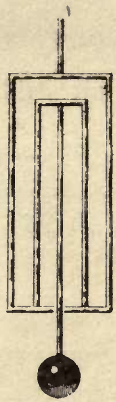

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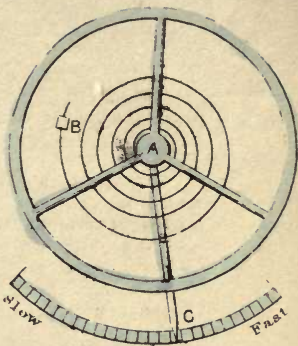

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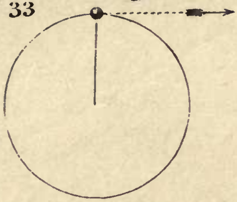

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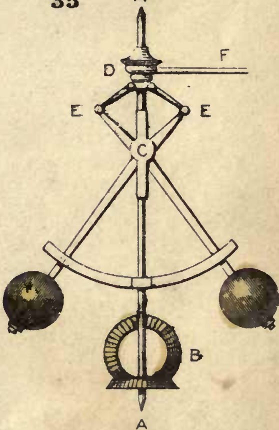

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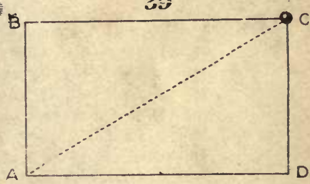

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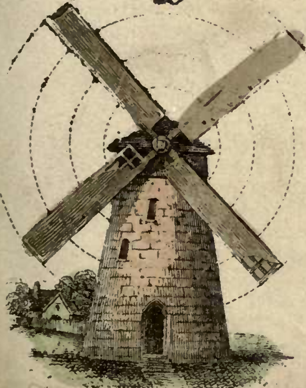

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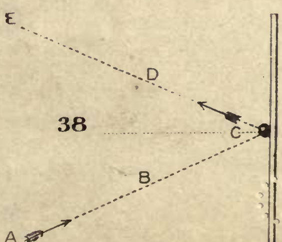

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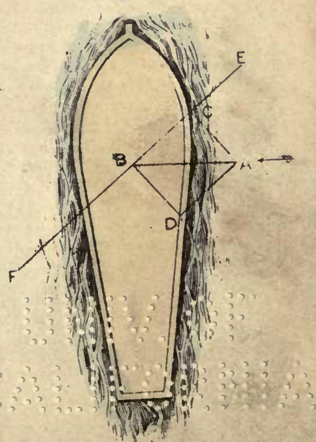
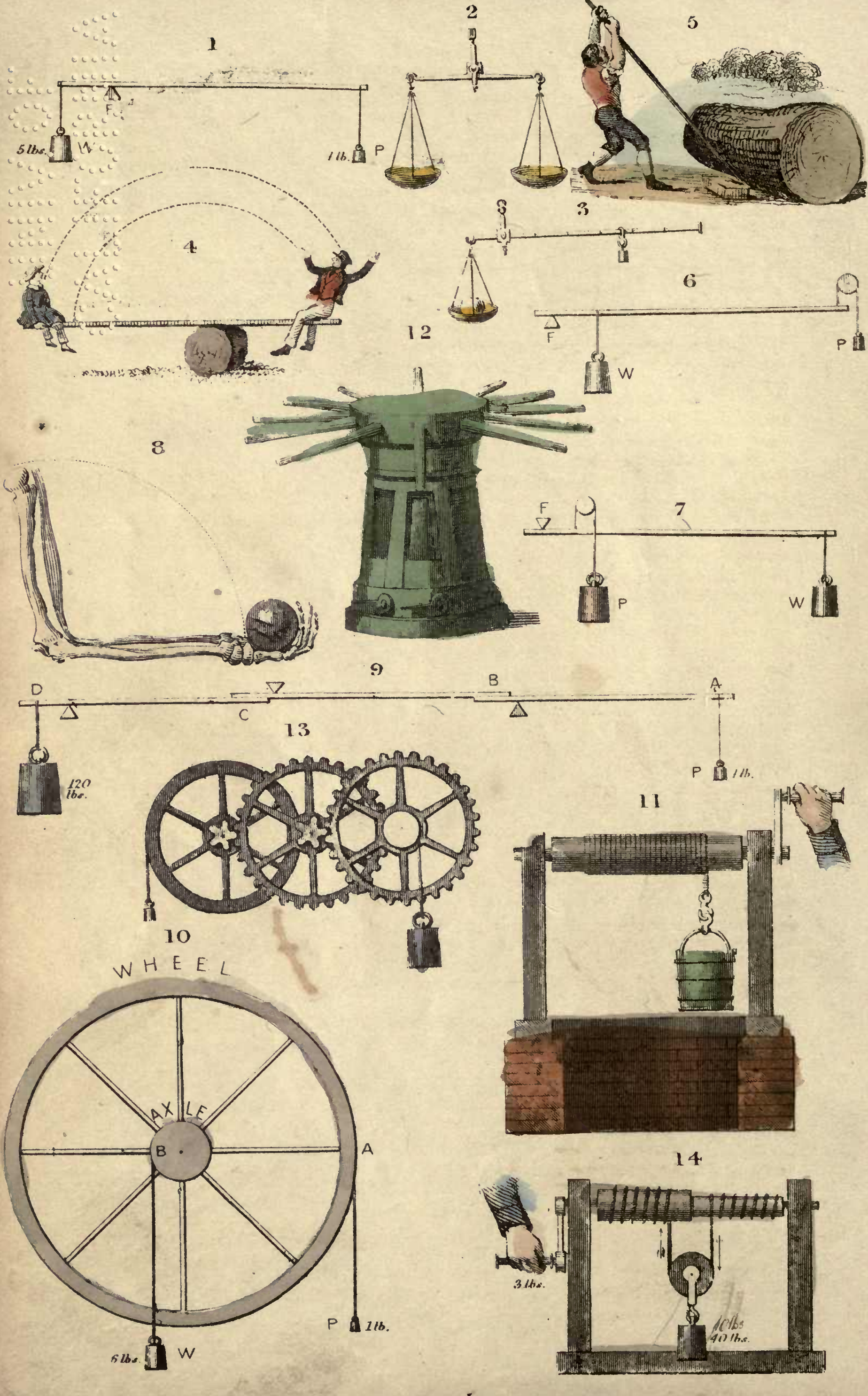


MECHANICAL POWERS



MECHANICAL POWERS.

THE mechanical powers are essentially but two in number, but are usually considered as six; namely, the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, and the Screw. The three first are assemblages of levers, and the three last inclined planes. One or more of these powers enters into the composition of every machine.

The Lever consists of an inflexible rod or bar, resting on a support called a fulcrum, for the purpose of raising, by a power applied at one end, a weight at the other. The advantage gained is in proportion to the greater distance of the power from the fulcrum, than is the distance from the fulcrum to the weight to be raised; thus, if the distance from the power to the fulcrum be five times greater than the distance from the weight to the fulcrum, a force of one pound in the power will balance five in the weight.

There are three kinds of levers; the *first* kind is that where the fulcrum (F) is placed between the weight (W) and the power, (P, fig. 1). The common balance, (fig. 2) is a lever of the first kind, as is also the Roman steelyard, (fig. 3).

The boy's amusement of see-saw (fig. 4) is another illustration of a lever of the first kind, the bigger boy taking the shorter end of the plank, that his lighter companion at the longer end may balance him.

Fig. 5, shows the application of a lever of the first kind in moving a heavy body; the nearer the fulcrum to the body to be moved the more powerful being the leverage.

In levers of the *second* kind, the weight is situated between the power and the fulcrum, (fig. 6). This kind of lever is seen in the common wheelbarrow, where the wheel is the fulcrum, the load in the barrow the weight, and the power the man who holds up the shafts. The oars of a boat present another instance; here the water is the fulcrum against which the blades of the oars press.

Levers of the *third* kind are those where the fulcrum is at one end, the weight at the other, and the power between them, (fig. 7). Here the power acts with a considerable disadvantage, and this kind of lever is only used where the object is to produce great velocity, and which can only be effected by an expenditure of power. The footboard of a common turning lathe affords an example of this kind of lever. But one of the most striking instances of it is seen in the human arm in the act of raising a weight in the hand, when the lower part of the arm becomes a lever of the third kind, the elbow joint being the fulcrum, and the muscles which move the arm, the power (fig. 8). The muscle, by contracting its fibres less than an inch, raises the hand twenty inches; and if it raises also a weight of twenty-five pounds in the hand, it must act with a force at least twenty times as intense, or of five hundred pounds; thus showing the extraordinary strength of the living muscle.

Levers may be *combined* in a great variety of ways, and the aggregate effect of such combination is as the product of the effect of the separate levers. Fig. 9, represents a combination of levers of the first kind, in which the power of the small weight P brings down A, which raises B, bringing down C, and consequently raising D; and thus, if properly supported, will balance the large weight W. By this means a weight of one pound will balance one of a hundred and twenty pounds.

The Wheel and Axle may be considered as a kind of perpetual lever, of which the fulcrum is the centre of the axis, and the long and short arms the radius of the wheel and the radius of the axle, as shown at fig. 10; the power P acting upon the weight W, through the intervention of the lever A B, whose fulcrum is the centre of the axle. Supposing the semi-diameter of the wheel to be six times greater than the semi-diameter of the axle, a power of one will balance a weight of six, exactly upon the principle of a lever of the first kind.

There are many modifications of this mechanical power; one of the most common is the windlass for raising water from a well by means of buckets, (fig. 11). The capstan used on board ships is an upright axle, the moveable bars or levers acting as the wheel (fig. 12). Like the lever, the wheel and axle may be used in combination, the circumference of one wheel acting by means of teeth upon the axle of another, as shown at fig. 13; the effect of such combination being similar to that produced by the combination of levers already described.

The compound axle, (fig. 14), is s contrivance by which the power is increased without increasing the diameter of the wheel. This axle has one half of it twice the diameter of the other half. A moveable pulley being attached to the weight to be raised, the rope is passed round the wheel, and coiled in the same direction upon both parts of the axle: upon every revolution of the axle, a portion of the rope equal to the circumference of the thicker part will be *drawn up*, but at the same time, a portion equal to the circumference of the thinner part will be *let down*: hence, every revolution of the cylinder raises the weight through a space equal to half the difference between the circumferences of the thicker and thinner parts of the axle.

The Pulley is a small wheel turning on an axis, and having a groove upon its circumference for the reception of a rope. It is either fixed or moveable. The *fixed* pulley (fig. 15) possesses no mechanical advantage, but is used to change the direction of the power, or to give convenience in pulling.

The *moveable* pulley, however, affords mechanical assistance by dividing the weight. This is illustrated at fig. 16, where the weight of the barrel is equally divided between the part of the rope affixed to the beam, and that held in the hand. Fig. 17 shows this more clearly; if the large weight be twenty pounds, ten pounds is borne by A, and ten pounds by P. The fixed pulley, B, is of no other use than to change the direction of the power.

The power of pulleys is increased by their combination. Fig. 18 illustrates this: here the weight is equally distributed between four ropes, consequently it may be supported by a power only a fourth of its own weight. Fig. 19 is a system of pulleys, or a *tackle*, as it is usually called, by which a power of one hundred will balance a weight of six hundred. Fig. 20 exhibits a system of pulleys in combination, in which a power of one will balance a weight of sixteen. The power of this system may be greatly augmented by substituting fixed pulleys for the hooks to which the ends of the ropes are attached, in the manner shown at fig. 21. In order to obviate the loss of power occasioned by the friction of the separate axles, where several pulleys are employed, an ingenious arrangement has been resorted to in White's patent pulley (fig. 22), by which all the pulleys in each block turn on the same axis.

The Inclined Plane. It is not difficult to understand that a body may with much greater ease be drawn up a slope, than it can be raised the same height perpendicularly. Hence the advantage of the inclined plane, which acts as a mechanical power, in partly supporting the weight (fig. 23). The longer the inclined space is in proportion to the perpendicular height, the greater is the advantage afforded. Suppose the inclined plane A B (fig. 24), to bear the proportion to the perpendicular height B C, as three to one, then a power of one will balance a weight of three.

Persons have often been struck with astonishment when viewing Stonehenge, how those enormous cross-pieces of stone were raised to the elevation at which we see them, but the mechanical feat is by no means very wonderful, for it would only be necessary to raise an inclined plane of earth in the direction of the line A B (fig. 25), and by means of rollers placed under the stone, pass it to its situation on the top; the earth being removed, the stone would remain secure.

The Wedge is a combination of two inclined planes united at their base (fig. 26). The wedge derives its great power chiefly from the way in which the force is applied—by being struck.

The Screw is a machine of great mechanical power, and is a modification of the inclined plane, as will be seen by reference to fig. 27. The screw has no power by itself, it can operate only by working in spiral grooves corresponding to its threads: these grooves are formed on the inside of a box or nut, through which the screw winds itself. Fig. 28 shows the screw, and its nut, fig. 29, exhibits the screw with a section of the nut, showing the spiral grooves, The power is applied by a lever, the screw, therefore, acts with the combined power of the lever and the inclined plane, thus becoming in reality a compound machine.

Screws are much used in presses of all kinds. The bookbinders' standing press (fig. 30), affords one of the best examples of this application of its power.

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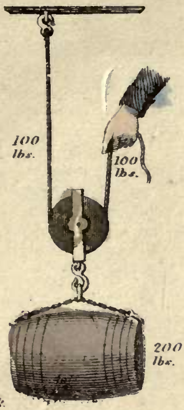

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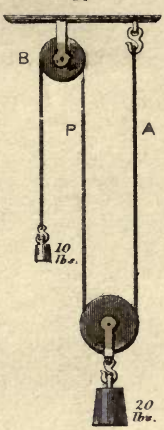

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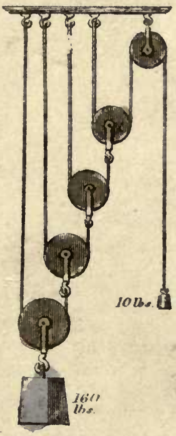

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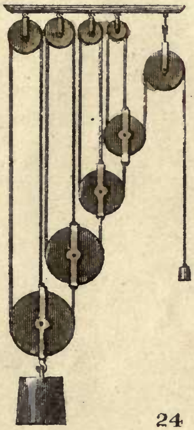

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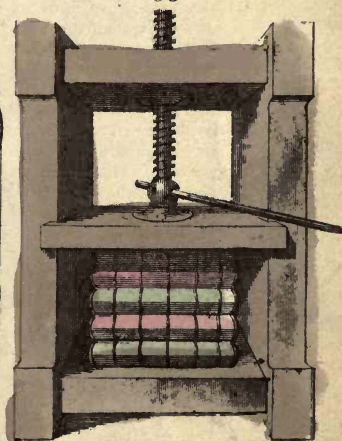

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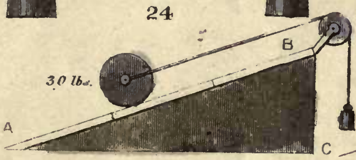

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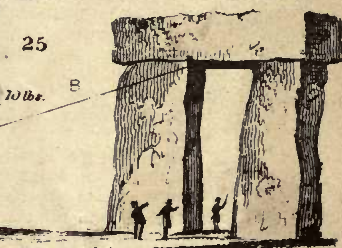

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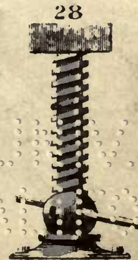

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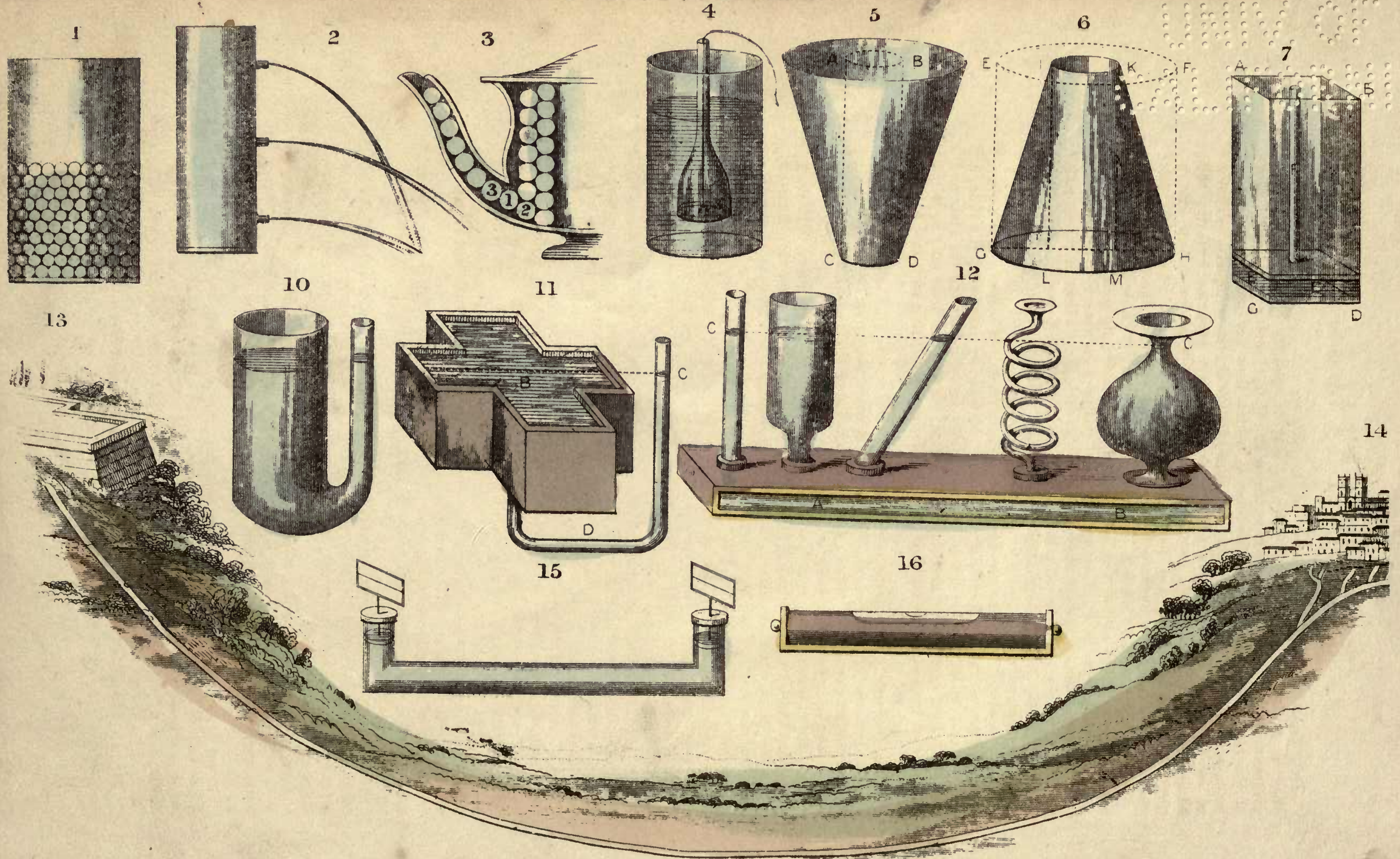
HYDROSTATICS



HYDROSTATICS.

This department of science treats of the pressure and equilibrium of liquids, the most remarkable property of which is, that of *equality of pressure*. This property arises from the extreme minuteness and independent gravitation of each of the particles, and from the manner in which they act upon each other; being arranged, not perpendicularly one above the other, but obliquely, as shown at fig. 1. One particle above pressing between two particles beneath, the latter consequently sustain a lateral pressure, just as a wedge driven into a piece of wood separates the parts laterally. This lateral pressure is the result, therefore, of the pressure downwards, or the weight of the liquid above.

Fig. 2 illustrates the different degrees of force with which water flows from apertures in a vessel at different heights. Fig. 3 represents part of a teapot, which we suppose to be filled with columns of particles of water; the particle 1, at the bottom, will be pressed laterally by the particle 2, and thus be forced into the spout, where, meeting with the particle 3, it presses it upwards, and this pressure will be continued till the water in the spout has risen to a level with that in the pot.

Fig. 4 is another illustration of the upward pressure of water. A is a glass tube, widened at the lower end, against which, by a string passing up the tube, a thick piece of metal is held close by the hand. Upon immersing the glass and plate thus held together in the water to a certain depth, the hand may be withdrawn from the string, the upward pressure of the water being sufficient to support the piece of metal.

Several interesting illustrations can be offered to prove the remarkable fact, that the pressure of water on the bottom of the containing vessel does not at all depend on the quantity of water, but upon the size of the base and the perpendicular height at which the water stands.

Figs. 5 and 6 represent two vessels of precisely similar capacities, and each containing the same quantity and weight of water, but which have very different pressures upon their bottoms; that upon C D being less than the absolute weight of the water, viz., the weight only of the cylindrical column, A B C D; while that upon G H is more than the absolute weight of the water, viz., the weight of a cylindrical column, E F G H, for the water in the central column G H I K, presses laterally with the same force, as it does on the part on which it stands; and thus an uniformity of pressure is exerted over every part of the bottom.

Fig. 7 illustrates the latter case still more strikingly: F is a tube communicating with the chamber, E E, and on these being filled with water, the pressure upon the bottom, C D, will be precisely the same as if the whole space, A B C D, were filled with water.

Fig. 8 represents the hydrostatic bellows, which has been contrived to exemplify the great effect of a column of water. The tube A communicates with the interior of the bellows, and upon these being filled with water, the upper board, B will be raised, and enabled to sustain a very considerable weight; for if the tube A hold but an ounce of water, and have an area equal to the thousandth part of the area of the top of the bellows, the ounce of water in the tube will sustain a thousand ounces placed on the bellows.

Another important principle in reference to liquids is their tendency to seek an uniform level. If we pour water into a bent tube, as fig. 10, it will stand at as equal height in both limbs.

If there be two tubes or limbs of a tube connected together, however different their width or form may be, a liquid poured into them will stand at the same level in both, and thus a portion, however small, will balance a portion, however large, as shown at fig. 11.

Fig. 12 represents a number of vessels of different forms fixed in the vessel A B, so as to communicate with it, and by means of it with each other. Water being poured into any one of them will stand at the same level in all, as shown by the line, C C.

From these considerations, a most important conclusion follows, namely, that water will, by being confined in pipes or close channels, rise to the height from whence it came; and upon this principle depend all the useful contrivances for conveying water into towns and houses by pipes from distant reservoirs. References to figs. 13 and 14 will illustrate this more clearly.

Fig. 15 represents the water level, and fig. 16 the spirit level.

Intermitting Springs.—Those springs which flow and stop by regular a ternations may be accounted for upon the principle of the syphon, represented at fig. 17. If this tube be filled with water, and the shorter leg be plunged into a vessel of water, the water will flow up the tube, over the bend, and out at the longer leg, till the vessel is emptied.

Fig. 18 represents a section of a hill, having within a cavity, A, from which runs a channel in the form of a syphon; the rain falling upon the hill, precolates through the crevices and pores, *d d d*, and in course of time will fill the cavity with water up to the level, E E; it will then flow over the bend, B, and continue to flow and supply the spring till the level of the water falls below the mouth of the channel, when the action of the syphon will cease, until, by fresh supplies, the level of the water is again raised, so as to flow over the bend, when the syphon will act as before.

The Hydrostatic Press.—Fig. 19. This is perhaps the most powerful machine ever invented, the only assignable limits to its power being the strength of the materials of which it is formed. A is the force pump, by the action of which water is forced through the small tube, B B, and its pressure communicated to the mass of water in the cylinder, C, there the water in its endeavour to resist compression forces up the moveable piston, D D, with its burden, and the action of the pump being continued, the pressure is gradually increased until the required degree is produced.

Fluid Support—Specific Gravity.—A solid body immersed in a fluid displaces exactly its own bulk of fluid, and the force with which the body is buoyed up, is equal to the weight of the fluid which is displaced; therefore, the body will sink or swim, according as its own weight is greater or less than the bulk of the displaced fluid. This refers to bodies of less density than water. Any body of greater density than water, when wholly immersed in that fluid, loses exactly as much of its weight as the weight of an equal bulk of the water which it displaces.

These laws are of much importance, as an acquaintance with them enables us to explain innumerable phenomena in nature, in reference to the floating of bodies in water, or in the atmosphere.

Fig. 20 is a vessel of water, and A a solid body of the same density immersed in it, and which, being equally pressed upon from above and below, retains its position, just as the mass of water it has displaced would have done. But if a solid body as B, fig. 21, heavier than water, bulk for bulk, be placed in it, it will sink to the bottom; while a body lighter than water will float on the surface partially immersed, as A, fig. 21, the weight of the water displaced being equal to the weight of the whole solid. Thus, the weight of any floating body may be ascertained by measuring the quantity of water which it displaces.

Fig. 22 represents the hydrostatic balance used for ascertaining the specific gravity of solid bodies, which are suspended in water by a horse-hair attached to the bottom of the scales.

Hydrometers.—These are instruments which, being immersed in liquids, determine the proportion of their densities, or specific gravities, and thence their qualities. The use of the hydrometer depends on the following propositions:—1. The hydrometer will sink in different fluids in an inverse proportion to the density of the fluids. 2. The weight required to sink a hydrometer equally far in different fluids will be directly as the fluids. Each of these two propositions gives rise to a particular kind of hydrometer; the first with the graduated scale, as fig. 23, the second with weights, usually hollow glass beads of various weights, which are dropped into the liquid till one is found to remain stationary, indicating the density of the liquid.

Fig. 24, represents Nicholson's hydrometer, consisting of a hollow copper ball A, with a steel stem B, supporting a small dish C. By the successive addition of weights to the dish C, the instrument may be sunk so as to obtain the complete range of specific gravity.

Fig. 25, represents the areometer, an instrument for determining the relative specific gravities of any two fluids which may be poured together without mixing, as mercury and water, oil and water, &c.

HYDRAULICS

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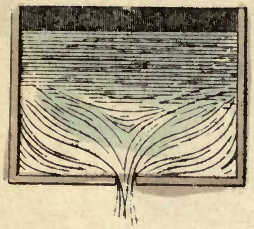

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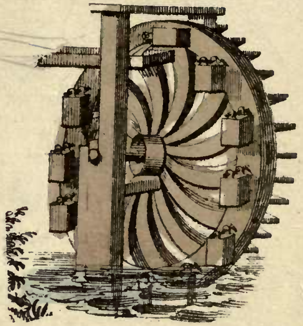

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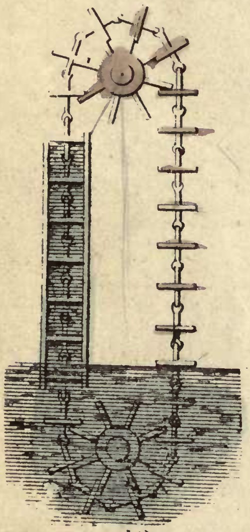

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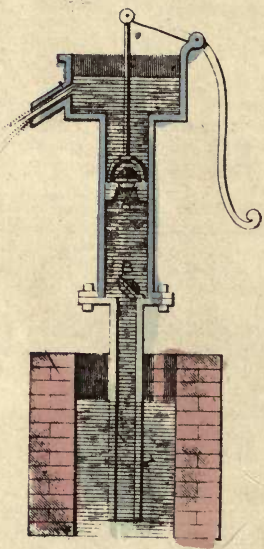

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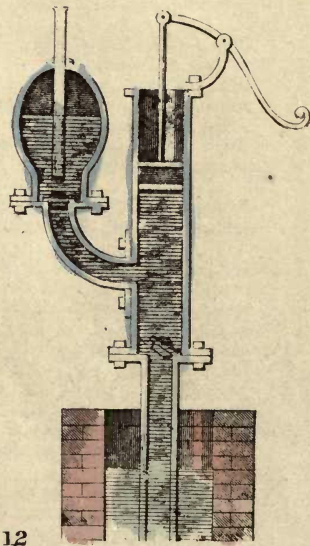

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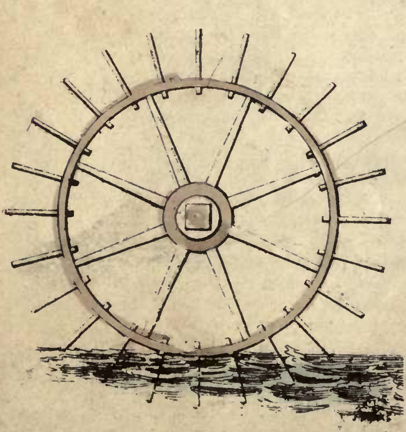

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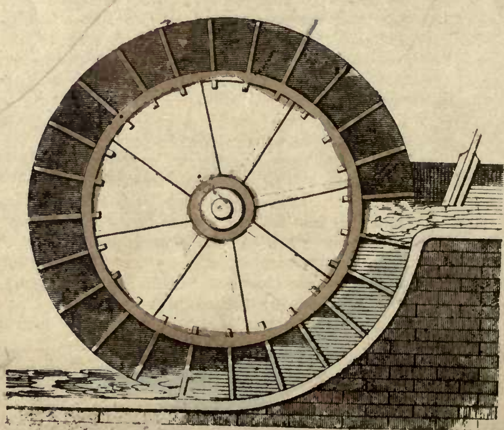

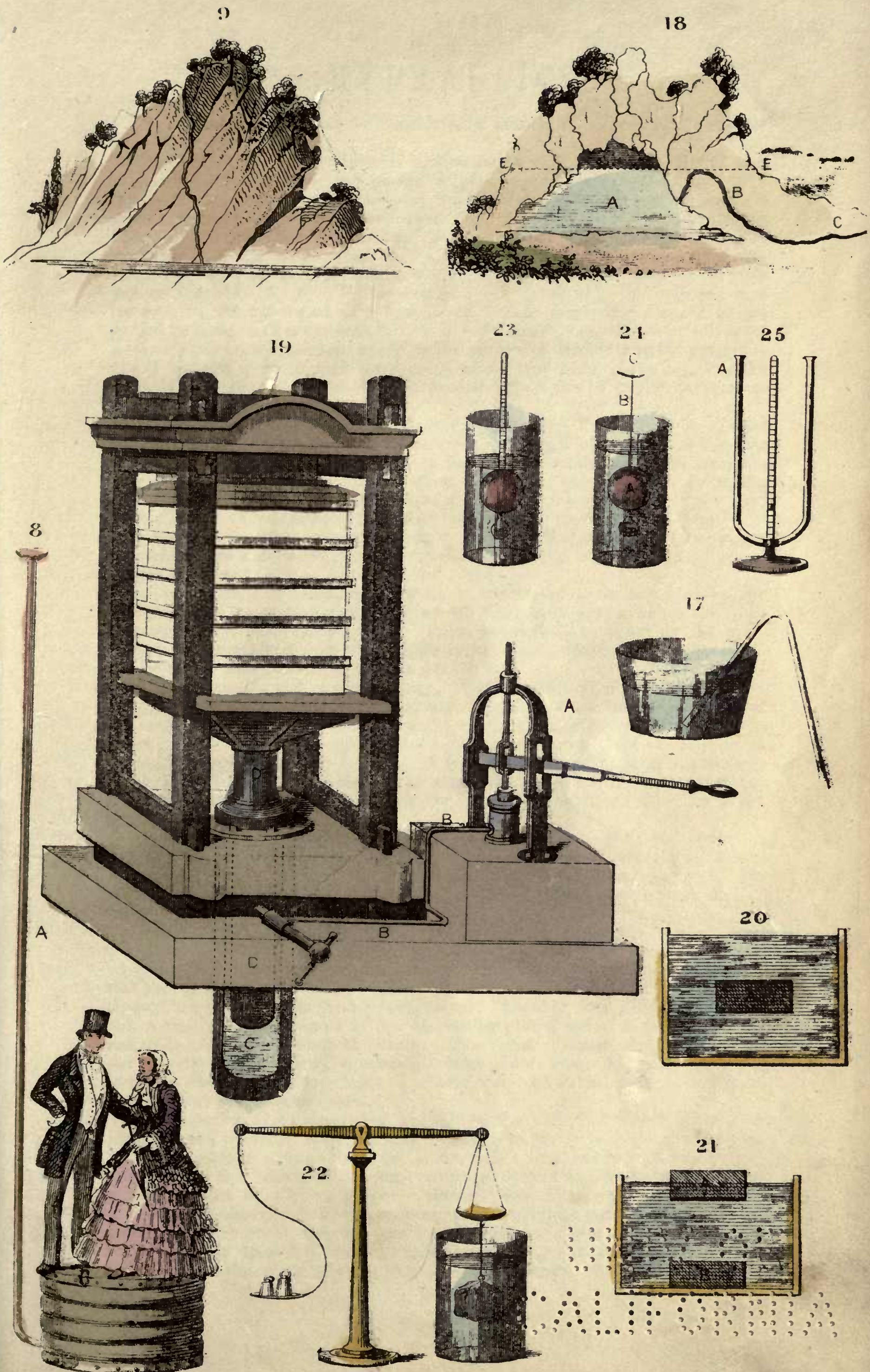
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HYDRAULICS.

THIS science, which may be considered a branch of hydrostatics, treats of liquids in motion.

The particles of liquids flow over and amongst each other with less friction than over solid substances, and all the substances gravitate independently. If a hole be made in the bottom of a vessel the liquid will flow out; those particles directly over the orifice being discharged first, their motion causes a temporary vacuum, into which the particles tend to flow from all directions; and thus the whole mass of the water is set in motion (fig. 1). As water flows through bended pipes to the same level from whence it proceeds, it enables us to form jets or fountains (fig. 2). If, for example, a body of water be collected in a reservoir on the upper part of a house, and a tube descending from it to the garden be made to turn upwards, having a very small bore, the water will spurt up in a jet to nearly the same height as the surface of the water in the reservoir. It will not rise quite so high on account of the resistance of the air, and the effect of gravitation. Most of the ornamental fountains in public gardens are formed upon this principle.

Pumps and Machines for Raising Water.—These may be divided into four classes. First, those machines in which water is lifted in vessels by the application of some mechanical force to them. The earlier hydraulic machines were constructed on this principle; such as the Persian wheel (fig. 3), consisting of upright buckets attached to the rim of a wheel moving in a reservoir of water; the buckets are filled at bottom as they pass through the water, and emptied at top; the water is thus raised to a height equal to the diameter of the wheel. The Archimedean screw (fig. 4), and the chain pump (fig. 5), are modifications of the same principle.

The second class of machines are those in which the water is raised by the pressure of the atmosphere, and comprises all those machines to which the name of pump is more particularly applied. These act entirely by removing the pressure of the atmosphere from the surface of the water, which may thus be raised to any height not exceeding thirty-two feet.

Fig. 6 represents the common pump, which consists of a cylinder, with an air-tight piston, having a valve, A, opening upwards. When the piston is raised a vacuum is raised in the tube beneath, which is immediately occupied by the water; on depressing the piston, the water passes through the valve, A, in its centre, and on being raised, the water is lifted to the top of the barrel, and flows through the spout. To prevent the water returning to the well when the piston is depressed, a valve (B) opening upwards is placed near the bottom of the pump.

When it becomes necessary to raise water to a greater height than thirty-two feet, the third class of machines, or those which act by compression on the water, usually by the intervention of compressed air, are employed. All pumps of this description are called *forcing pumps*, and by these water may be raised to any height by applying sufficient force.

Fig. 7 represents the forcing pump, consisting of two parts, or barrels, one similar to the common pump, and the other rising by its side. The water is first raised in the former part in the same manner as in the common pump, excepting that the piston has no opening valve, but is solid, and the air is forced out through the valve, A, into the adjoining barrel. Through this valve the water is also forced, and the pressure of the descending piston causes it to flow up the ascending pipe and issue out of the top. The vessel in which the lower end of the ascending pipe is placed, encloses a volume of air; when the water rises this air is compressed, and being elastic it re-acts upon the water, thus causing it to flow upwards with greater force.

The fire-engine is an interesting example of the utility of this machine; its principle will be readily understood by reference to fig. 8. A is the suction-pipe by which water is supplied from the street main; B B are two valves opening upwards into the barrels of two forcing pumps, containing solid pistons; from the lower sides of the pump-barrels proceed force-pipes, which communicate with an air-chamber, C C, by valves, D D, opening upwards into it. Through the top of the air-chamber descends nearly to its bottom a pipe, E E, to the upper part of which is attached the hose for directing a stream of water on the fire. By the alternate action of the pistons, water is drawn through the valves B B, and propelled through the forcing valves, D D; and the enclosed air being compressed, re-acts upon the water, which is projected up the centre pipe and along the hose with a force proportioned to the power applied to the pistons by the persons who work the engine.

The fourth class of hydraulic machines for raising water consists of such engines as act either by the weight of a portion of the water which they have to raise, or of the water, or by its centrifugal force, momentum, or other natural powers. The centrifugal pump (fig. 9) belongs to this class. This machine raises water by means of the centrifugal force, combined with the pressure of the atmosphere. A B is an upright spindle, so fixed that rapid rotary motion may he communicated to it by a wheel and pinion, or winch. C D, C D, represent any number of curved pipes so disposed and fixed to the spindle that their lower ends may be near to it, and be covered by the water to be raised, and their upper ends to be extended to a considerable distance from the centre of motion, and bent downwards to prevent the scattering of the water. Before putting the machine in action the several pipes must be filled with water, which will be retained in them by a valve near the bottom opening upwards. The machine is then put in motion by turning the spindle rapidly. The upper ends of the pipes will describe a much larger circle than the ends below, and, consequently, such a centrifugal force will be generated at the upper ends as will produce a vacuum, and the water below will then rise and flow from the upper ends of the pipes into the circular trough, whence it may be delivered by a pipe as required.

Power to be derived from Water.—Motion is generally obtained from water either by exposing obstacles to the action of its current, as in water-wheels, or by arresting its progress in moveable buckets or receptacles, which retain it during its descent A water-wheel consists of a hollow cylinder or drum, revolving on a central axle, from which the power is communicated; while the exterior surface is occupied by float-boards, or cavities upon which the water is to act. Water-wheels are divided into three classes—first, the *Undershot* wheel (fig 10), having floats dipping into the water, the current of which, acting against them, causes the wheel to revolve. The second class are those termed *Overshot* wheels (fig 11), in which the circumference is occupied by a series of cavities, into which the water falls from above; as the wheel revolves these cavities become inverted and discharge their contents at the bottom of the wheel. This description of wheel is much more powerful, as well as much more economical in its consumption of water, than the preceding. The third kind of water-wheel is that termed the *Breast* wheel. In this the water is delivered about half-way up it, or rather below the level of the axis, and the brickwork upon which the water descends is built in a circular form, so as to make it parallel to the edges of the float-boards of the wheel; its arrangement and mode of action will be readily understood by reference to fig. 12.

Fig. 13 represents Barker's mill, a machine which owes its efficacy to the centrifugal force. It consists of a long cylindrical pipe, having a funnel at A, and terminating in a pivot, turning in a socket, at B. About A is an axis C, passing through a frame, and carrying with it the upper millstone. At the bottom of the pipe at B, is a cross pipe, D E, at the opposite sides of which are two apertures, from which the water poured into the funnel at A, spouts with considerable velocity, and, from the resistance of the air, gives motion to the machine.

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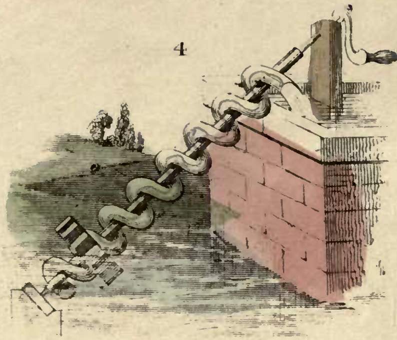

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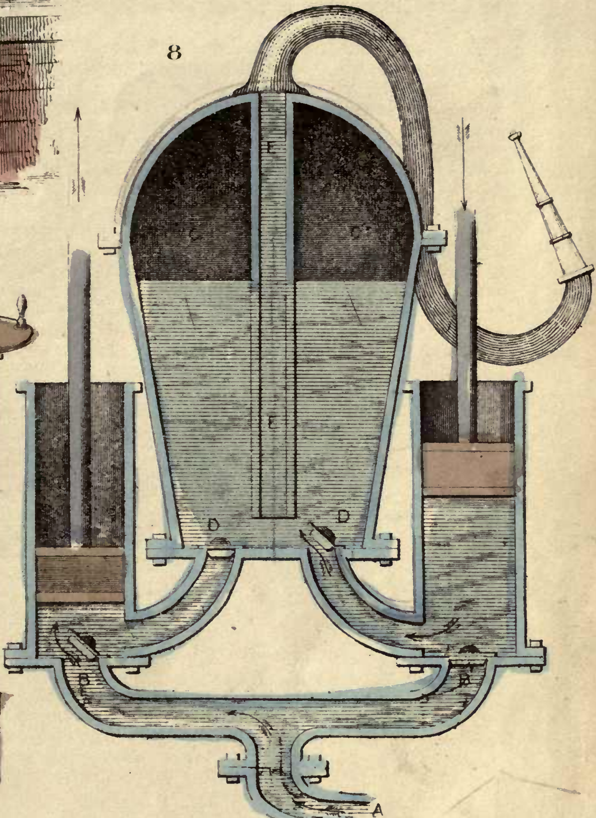

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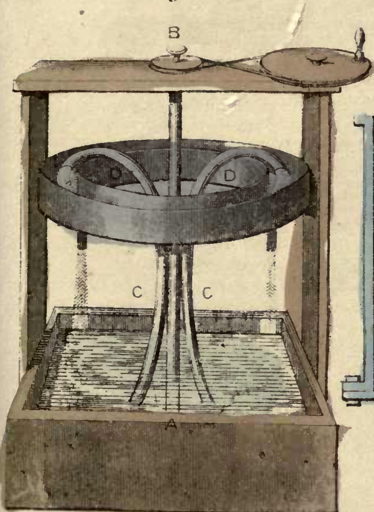

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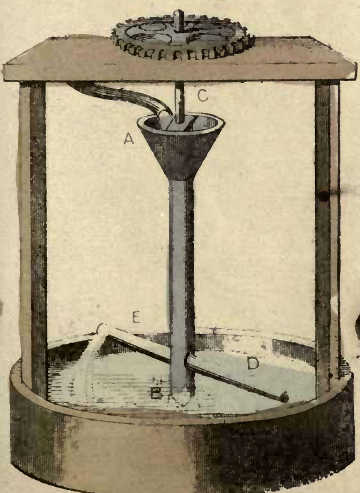

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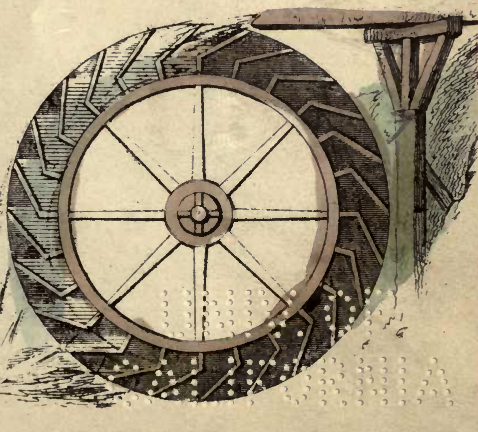

PNEUMATICS

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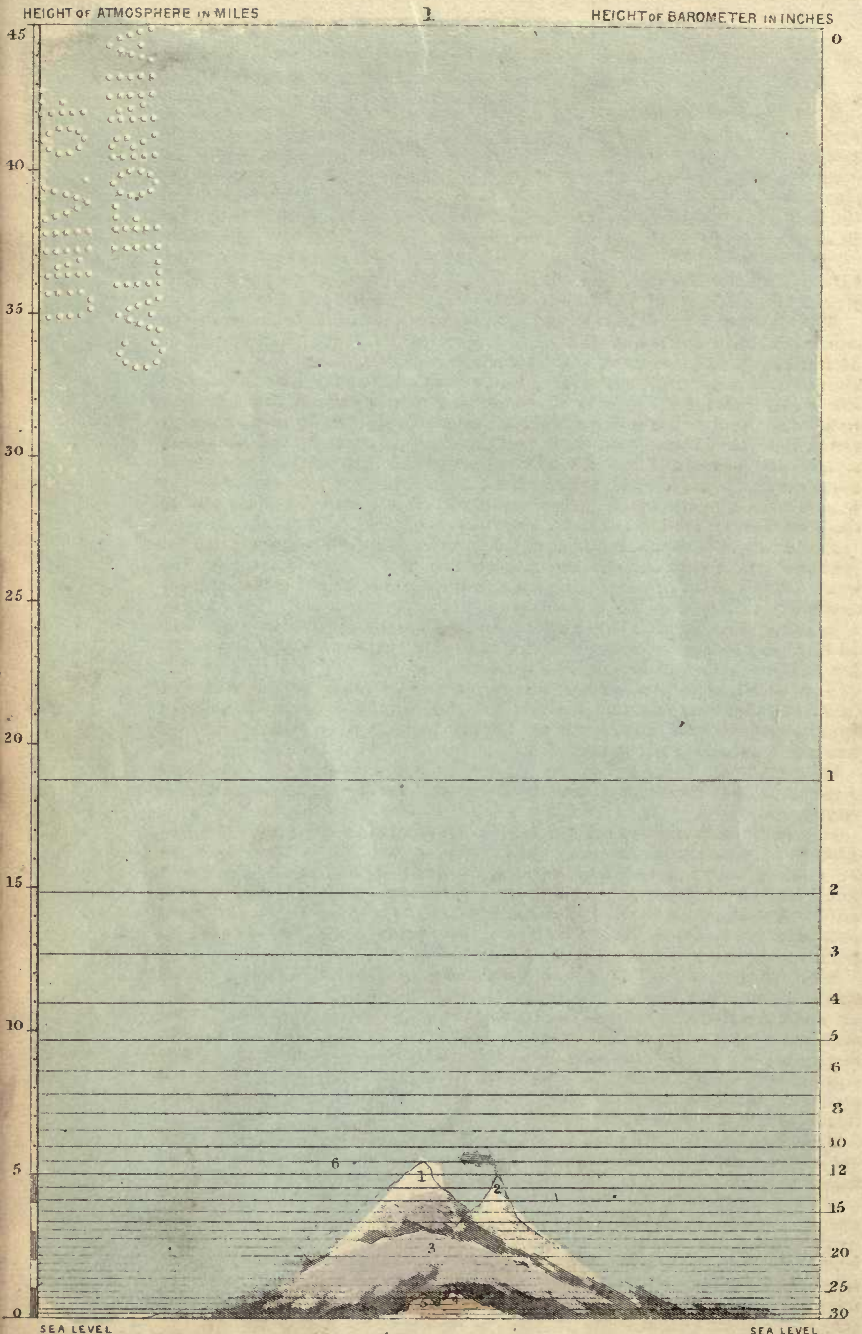

1 Himalaya 28,000 feet. 2 Andes 25,250 feet. 3 Alps 15 650 feet. 4 Ben Nevis 4,350 feet.
5 Snowdon 3,571 feet. 6 Mr Green's Balloon in 1837, 27,000 feet.

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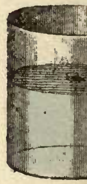

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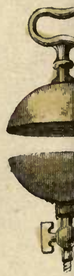

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PNEUMATICS.

This branch of science treats of the nature and properties of the atmosphere, and of their effects upon solid and fluid bodies. The atmosphere is a thin gaseous substance, which envelopes the earth on every side to the height of about forty-five miles, its density decreasing with its height. Fig. 1, represents the atmosphere, which is divided by lines into thirty spaces, each of which contains the same quantity of air, the lower layers being so much compressed by the weight of those above them, that the lower half of the atmosphere lies within about three and a half miles of the earth's surface, while the upper half is so expanded as to occupy upwards of forty miles. The upper thirtieth part alone occupies more space than all the remaining thirty-nine parts.

Mechanical Properties of Air.—The most essential point in which air differs from other fluids is by its elasticity; that is, its power of increasing or diminishing its bulk, according as it is less or more compressed. Air possesses the universal properties of matter. Its impenetrability may thus be shown: Fig. 2, is a vessel partly filled with water, upon the surface of which floats a small cork; fig. 3 is a smaller cylindrical glass vessel, with a stop cock, which is closed. If this vessel be inverted over the cork, as at fig. 4, and its mouth pressed into the water, it will be fonud that the water will not enter the inverted glass, except to a very limited height, owing to the air in the glass excluding the water; but if the stop cock be opened, the air will escape, and the water rise to the same level within as it is without the glass.

That air is inert and moveable, we have many and familiar proofs, as the resistance it offers to a body passing through it, and the force exerted by the wind. It also possesses weight, one hundred cubic inches weighing about thirty-one grains.

Laws of Air.—First, the pressure of the air is equal in all directions; second, its degree of pressure depends on the vertical height, and is in proportion to its density, and to the weight of the fluid displaced.

That air presses in all directions may be proved by filling a bladder with that fluid, and then pressing upon it; the pressure will be freely communicated through the mass, and the confined air will rush out with equal force at whatever part a hole is made in the surface.

The pressure depending on vertical height or depth of air, is an important property of the atmosphere, and on it depends the explanation of numerous phenomena.

Air being a substance possessing gravity, necessarily presses downwards in the direction of the centre of the earth; and, therefore, the degree of pressure on any given point will be equal to the weight of the column of air above that point, and proportional to its density. The atmosphere is of the greatest vertical height at the level of the sea, and here its pressure is about fifteen pounds on every square inch of surface. The pressure being exerted upwards sideways, obliquely, and in every other direction, as well as downwards.

Some illustrations may be given of the pressure of the air. Figs. 5 and 6 represent two hollow hemispheres of brass; these being placed in contact and the air withdrawn from the interior, the external air will exert a pressure of 15 lbs. upon every square inch of their surface, so that if two persons pull the handles in opposite directions they will be unable to separate the hemispheres. The common leather sucker (fig. 7) with which boys raise stones, acts from the pressure of the atmosphere. It is the pressure of the atmosphere which causes liquids to rise in pumps and syphons.

The Barometer. This instrument consists of a column of mercury, supported in a tube by the pressure of the atmosphere, and therefore indicating that degree of pressure (fig. 8). It is formed by a glass tube about 34 inches long, closed at one end and open at the other. The tube being filled with mercury, the open end is stopped with the finger to prevent any running out, and the tube being inverted, the open end is placed in a small cup of mercury, and the finger being withdrawn, the mercury in the tube now subsides three or four inches, above the top of which in the tube is a perfect vacuum. The tube being then fixed to a graduated frame, we have a barometer. The mercury will stand in the tube at the height of from 28 to 30 inches, according to the state of the air; and the reason of this is, that the pressure of the whole atmosphere will not raise a column of mercury higher than about 30 inches; that is, a column of air equal to the height of the atmosphere, from the level of the sea, is of the same weight as a column of mercury 30 inches high, the one thus balancing the other. The figures at the sides of fig. 1, show the height of a column of mercury at different elevations: the barometer thus becomes an important means of determining the altitude of mountains.

The wheel barometer is represented at fig. 9. The tube is closed at the top, and bent upwards at its lower extremity, which is open, and the mercury buoys up a small float, F, to which a thread is attached, passing over a pulley and terminating in the little ball, W. The friction of the thread on the pulley turns an index which points to the words on the dial plate.

When the mercury falls in the barometer, an indication is given of diminished pressure; and as this causes the air to expand and become sensibly cooled, moisture is likely to be precipitated in the form of rain.

The Air Pump.—Air may be artificially withdrawn from a containing vessel by means of an apparatus called the air pump, represented at figs. 10 and 11 (the latter showing the pistons and valves). A is the receiver, resting in close contact with the pump plate B, near the centre of which is the open end of the tube C C, communicating with the exhausting barrels D D; these are fitted with pistons having valves opening upwards, so as to allow the air beneath to pass out but preventing its return. At the bottom of the barrels are two other valves also opening upwards, admitting the air from the tube into the barrels when the pistons are raised, and on their descent preventing its return; the air thus confined in the barrel, by the descent of the piston, becomes compressed, and forcing open the valve in the piston, escapes into the open air. The pistons are connected by a rack and pinion movement with a handle, and are raised alternately, thus producing a vacuum beneath the receiver. By means of the air pump many interesting experiments in pneumatics may be performed. When the air is thoroughly exhausted, light and heavy bodies fall with equal swiftness: most animals die immediately; vegetation stops; combustion ceases; gunpowder will not explode; heat is slightly transmitted; a bell sounds faintly; magnets are powerless; glowworms give no light; and watery and other fluids turn to vapour. We thus see the important uses of the air in supporting life, vegetation, and combustion; in forming a medium for conveying to us the sound of each others voices; besides contributing in numberless ways to our comfort and enjoyment.

Air Condenser.—Fig. 12 represents a section of the condensing syringe, having an opening at A to admit the air, and a valve at B opening downwards. The air being forced by the piston through the valve B, is prevented from returning by the form of the latter. Fig. 13 represents a vessel partly filled with water. By means of the condensing syringe, a large quantity of air may be forced through the tube into the space A A; the stop cock being then closed and the syringe detached, and the stop cock being again opened, the pressure of the air upon the surface of the water will force it up in the form of a jet d'eau. The elastic force of compressed air is very great, and is sometimes employed for the projection of balls from the air gun (fig. 14).

Air Balloon.—The air balloon (fig. 15) is a light silken bag of large dimensions, filled with a gas, which bulk for bulk, is lighter than air, so that, when inflated, the machine becomes lighter than the air which it displaces, and this difference is so considerable that it is enabled to carry up with it several persons in a car attached. As it ascends, the air becoming less dense, the difference between its weight and that of the air displaced is gradually diminished, until it attains such a height that the air it displaces is so rare, as to be only equal in weight to the balloon; this, therefore, becomes the limit of its ascent. In order to descend the bulk of the balloon is diminished, by the gas being allowed to escape by opening a valve; thus, the weight of the balloon is made to exceed that of an equal bulk of air and it accordingly falls.

The Diving Bell.—Fig. 16. This machine is formed of iron, and is usually capacious enough to hold three or four persons. It is constructed on the impenetrability of air, before described. Air is pumped in from above by means of a forcing air pump, or condenser; the water is thereby prevented from rising in the machine, and the persons within are enabled to breathe freely. A represents the pipe conveying the fresh air from force pumps, and B the pipe conveying the vitiated air from the bell.

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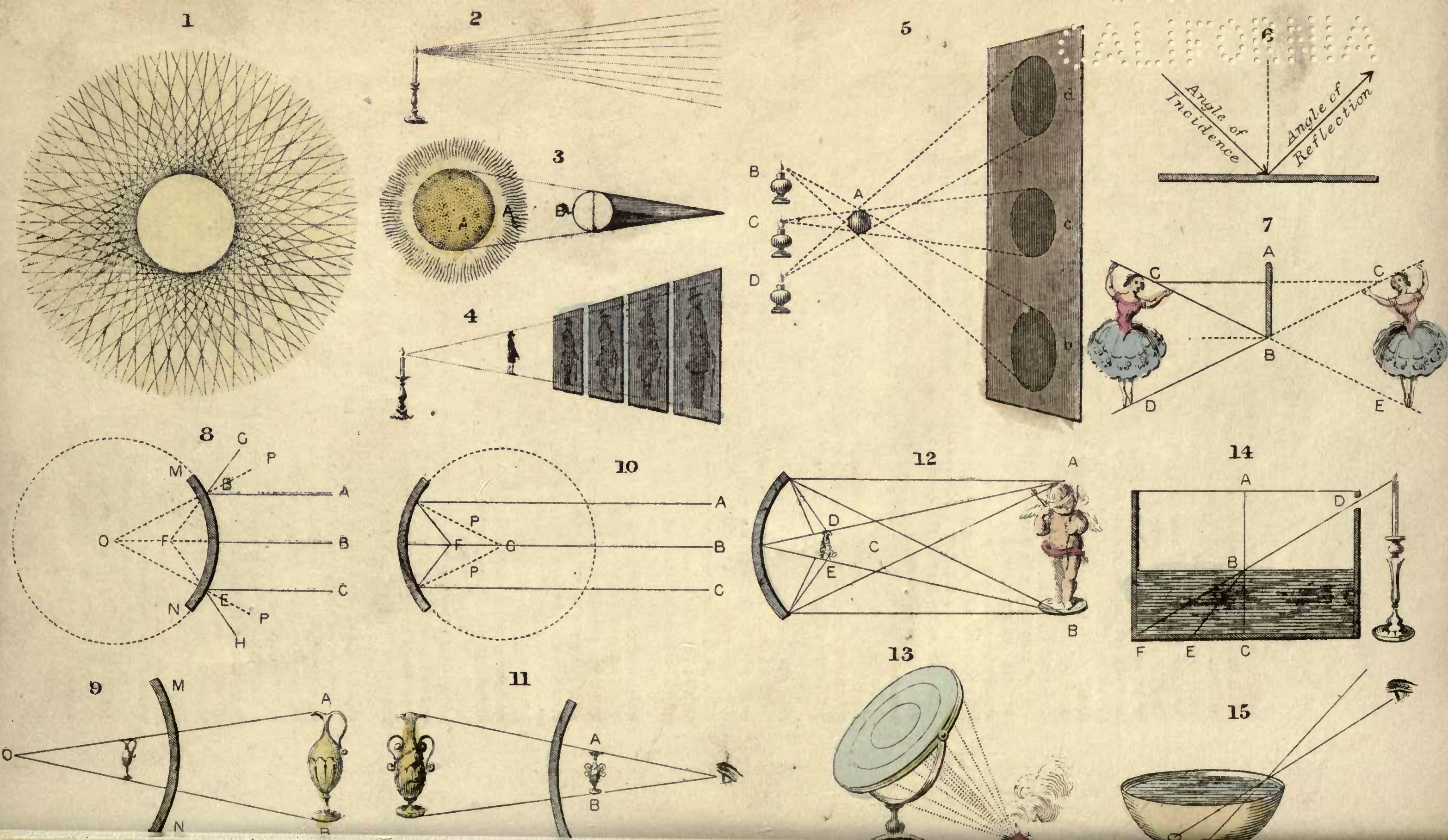
OPTICS



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OPTICS.

OPTICS is the science of light and vision.

All visible bodies may be divided into two classes—*self-luminous* and *non-luminous.* The first comprise those bodies which shine by their own light, as the stars, sun, flames, &c. Non-luminous bodies are those which have no power of discharging light of themselves, but which throw back the light that falls upon them from self-luminous bodies. Light emitted from a self-luminous body is projected in straight lines in every possible direction, so that the luminous body not only seems the general centre whence all the rays proceed, but every point of it may be considered as a centre which radiates light in every direction (fig. 1). A ray of light is a straight line of light projected from a luminous body, and a pencil of rays is a collection of rays proceeding from any one point of a luminous body (fig. 2).

When rays of light meet with an opaque body through which they cannot pass, they are stopped short in their course, and cause the opaque body to form a shadow on the other side of it. If the luminous body (as A, fig. 3) be larger than the opaque body (B), the shadow will gradually diminish in size till it terminates in a point; if smaller, the shadow will increase in size, as it is more distant from the object that projects it (fig. 4). A number of lights in different directions, while they decrease the intensity of the shadows, increase their number, which corresponds with that of the lights (fig. 5).

Reflection of Light.—When a ray of light falls perpendicularly on an opaque body, it is reflected back in the same line towards the point whence it proceeded; if it falls obliquely, it is reflected obliquely, but in the opposite direction, the angle of reflection being equal to the angle of incidence (fig. 6).

The principle of reflection may be illustrated by the case of a plane mirror or looking glass (A B. fig. 7). The ray from the eye of the spectator at C will be reflected in the same line C A; but the ray D B, coming from the foot, in order to be seen at the eye, must be reflected in the line B C, and therefore the foot will appear behind the glass at E, along the line C B E.

There are three kinds of mirrors used in optics; the plane or flat, the convex, and the concave. A convex mirror has the peculiar property of making the reflected rays *diverge*; and a concave mirror makes the rays *converge.*

M N, fig. 1, represents a convex mirror formed of a portion of the exterior of a sphere, whose centre is O. A B C are three parallel rays, the middle one of which only is perpendicular to the centre of the mirror, and is reflected in the same line; the two others falling obliquely, will be reflected obliquely to G and H, the dotted lines, P P, being perpendiculars which divide their angles of incidence and reflection. By continuing the reflected rays G B and H E, backwards, they will meet at F, their virtual focus behind the mirror.

If A B, fig. 9, be an object placed before the convex mirror (M N), and lines be drawn from its extreme points A B, to O, the centre of the sphere, a diminished representation of the objects will be formed at the focus.

Fig. 10 illustrates the property of a concave mirror. A B C are three parallel rays, which, striking the mirror, are reflected, the middle ray in the same line, and the two others converged so as to meet at the focus F, midway between the surface of the mirror, and the centre of its concavity C. The dotted lines P P, are perpendiculars.

Images reflected from concave mirrors appear larger than the real objects, provided these objects are within the focus, as A B, fig. 11.

A B, fig. 12, is an object placed at some distance in front of a concave mirror. In this case, a small and inverted image of the object will be formed at D E. When the object is placed at D E, a magnified representation of it will be formed at A B.

Concave mirrors are used as burning glasses (fig. 13).

Refraction of Light.—Refraction is the effect which transparent mediums produce on light on its passage through them. Opaque bodies *reflect* the rays; transparent bodies *transmit* them; but it is found that if a ray, in passing from one medium into another of different density, fall obliquely, it is turned out of its course, or *refracted;* but if it fall perpendicularly it is not refracted, but proceeds through the new medium in its original direction.

Let fig. 14, be a vessel half filled with water. If a ray strike it in the perpendicular direction, A B, it will be continued in the same line to C; but if a ray be admitted at D, it will strike the water obliquely at B, when it will become subject to two opposite forces, the attraction of the water endeavouring to draw perpendicularly to C, and the projectile force of the ray inducing it to proceed in its original direction to F; the consequence will be, that it will pursue an intermediate course to E.

If a coin be placed in a basin, so that on standing at a certain distance it be just hid from the eye of an observer by the edge of the basin, and then water be poured in by a second person, the first keeping his position, as the water rises the coin will become visible, and will appear to have moved from the side to the middle of the vessel (fig. 15).

These facts lead to an important axiom in optics; namely, that we see everything in the direction of that line in which the rays approach us last. Hence, the sun is seen several minutes before it comes to the horizon, and as long after it has sunk beneath it, because its rays strike first upon the atmosphere, and are by it refracted, or bent towards the earth (fig. 16).

In passing through a pane of glass the rays suffer two refractions, but which, being in contrary directions, produce nearly the same effect as if no refraction had taken place. A A, fig. 17, represents a thick pane of glass seen edgeways. When the ray B approaches the glass at C, it is refracted to D; at that point, returning into the air, it is again refracted, but in a contrary direction, and in consequence proceeds to E. But this is the case only when the two surfaces are parallel to each other; if they are not, the two refractions may be made in the same direction. Thus, when the parallel rays (fig. 18) fall on a piece of glass having a double convex surface, that ray only which falls in the direction of the axis of the lens is perpendicular to the surface: the other rays falling obliquely are refracted towards the axis, and meet at a point beyond the lens, called its focus.

Figs. 19 to 23 represent sections of lenses of various forms, having different refractive properties. The property of those which have a convex surface is to collect the rays of light to a focus; and of those having a concave surface to disperse them. The rays falling on the concave lens, fig. 25, will each be attracted towards its thicker extremities, both on entering and quitting it; and will, therefore, by the first refraction be made to diverge to A C, and by the second to *d e* The ray B, falling perpendicularly on the axis of the lens, suffers no refraction.

Lenses which have one side flat, and the other convex or concave, as figs. 19 and 20, are called plano-convex and plano-concave. The focus of the former is at the distance of the diameter of the sphere, of which the convex surface of the lens forms a portion, as shown at fig. 26.

Fig. 24 represents a section of a prism, the principal use of which is to enable us to decompose the rays of light.

Decomposition of Light.—White light, as emitted from the sun, or other luminous body, is found to be composed of seven different kinds of light; namely, *red*, *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet;* and this compound substance may be decomposed or separated into its elementary parts.

Fig. 27, represents a prism, so placed, that a beam of light, admitted by a small aperture, A, falls upon it, and being refracted is thrown upon the screen B C, forming an oblong image called the *prismatic spectrum*, containing the seven colours already named.

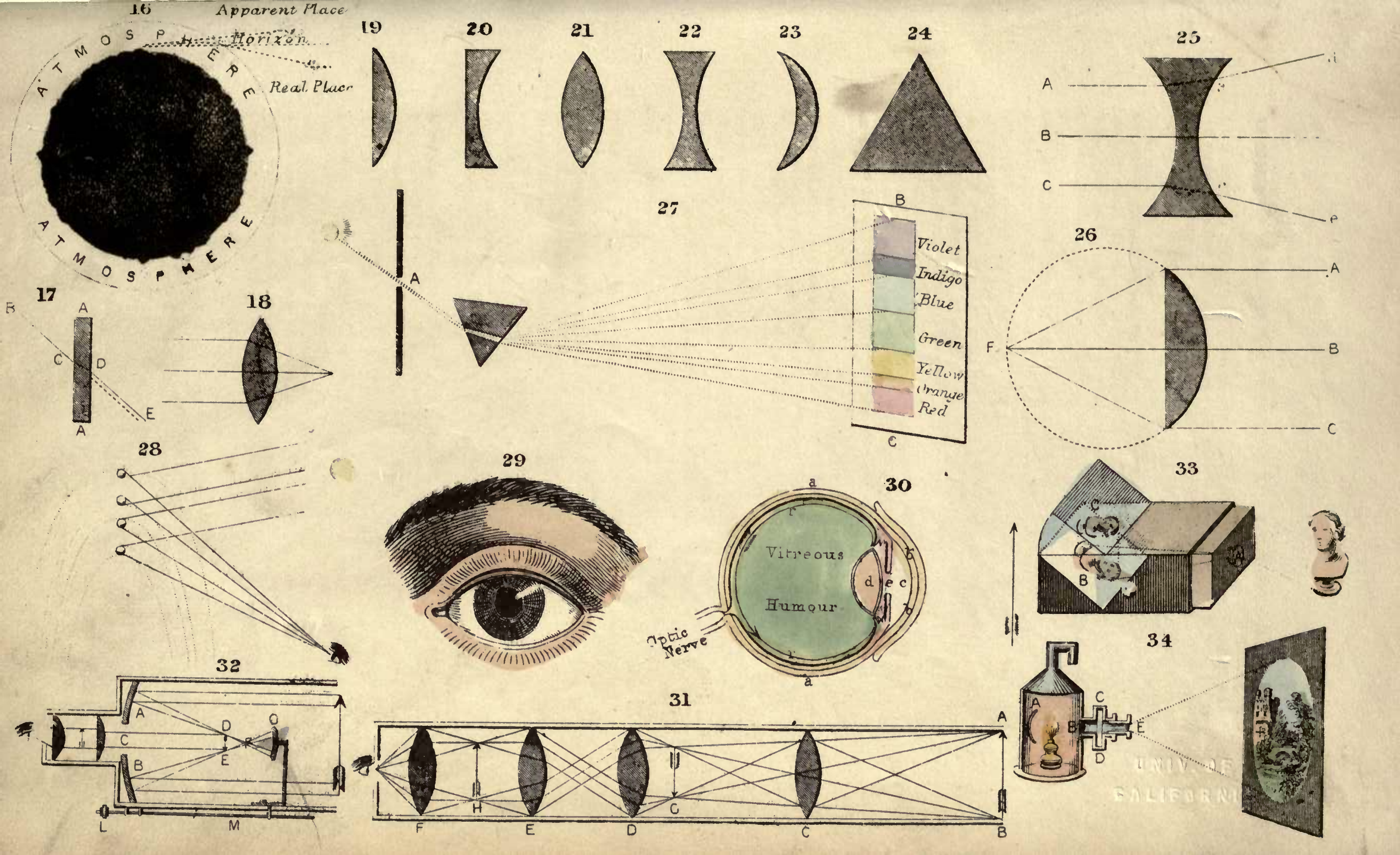
The Rainbow is formed by the sun's rays falling upon the upper parts of the drops of rain, and being then, by refraction, thrown on another part of the same drop, where they are again refracted and reflected to the eye, so as to produce the successive colours from the upper part of red, orange, yellow, green, blue, indigo, and violet (fig. 28).

The Eye—Vision.—Figs. 29 and 30 represent a front view and a section of the eye. The eye is composed of three coats or skins, one covering the other. Within the coverings of the eye-ball are contained three transparent substances, called *humours*. These different humours form a compound lens, which refracts the rays of light rebounding from objects, forming an image of them upon the retina, the sensation being transmitted by the optic nerve to the brain.

Telescopes.—Fig. 31 illustrates the construction and action of a refracting telescope, and fig. 32, that of a reflecting telescope. The lines show the direction in which the rays are transmitted through the various lenses.

Fig. 33 represents the *camera obscura*. This interesting optical instrument consists of a convex lens A, through which the rays of any objects are admitted into a darkened chamber, where they fall on a plane mirror B, placed at an angle of forty-five degrees; by this they are reflected upwards against a plate of ground glass C, upon the upper surface of which the objects appear in their natural colours

Fig. 34 represents that well known instrument, the *magic lantern*.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ATMOSPHERE
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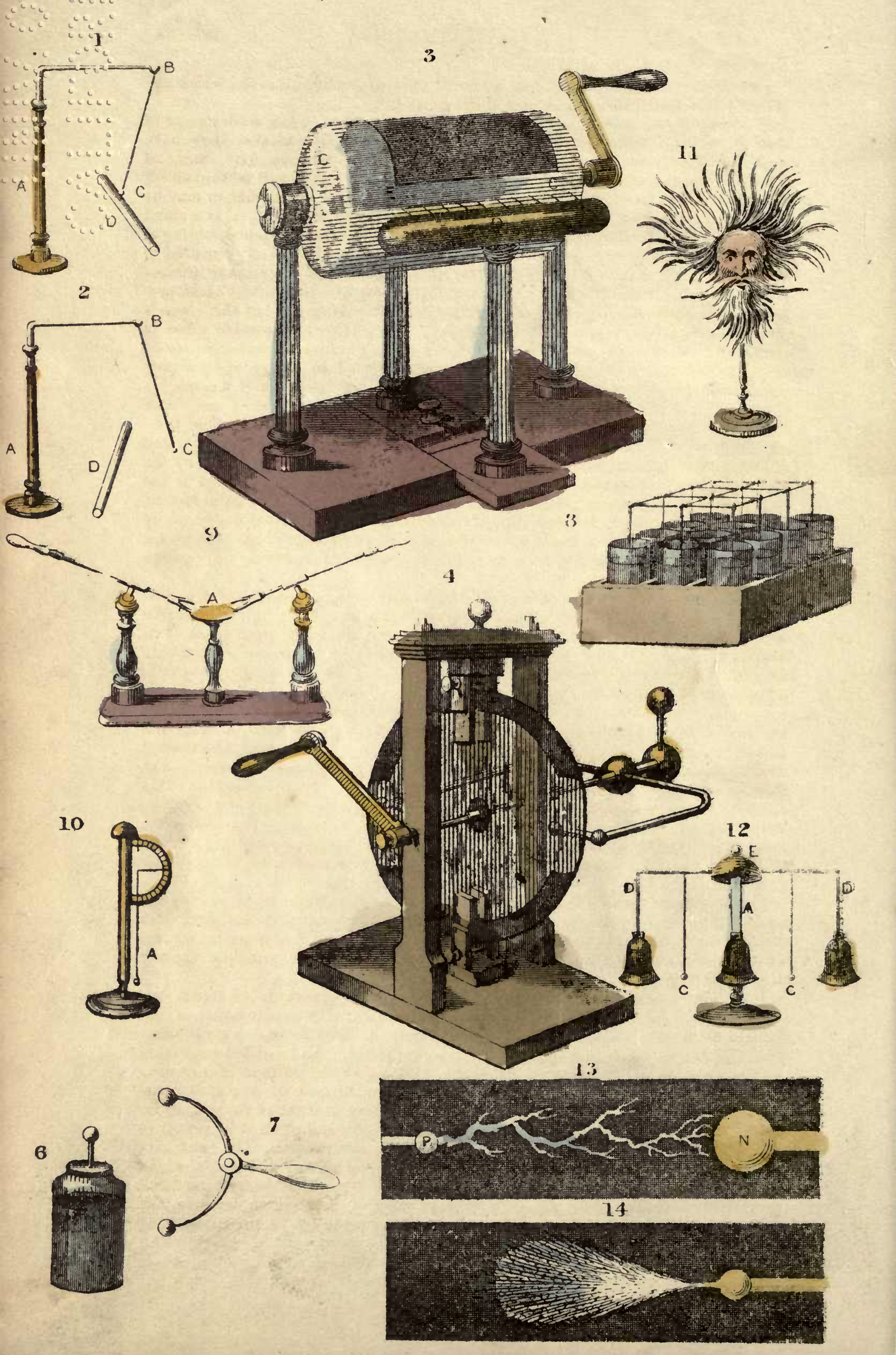
ELECTRICITY



ELECTRICITY.

Electricity is the operation of a subtile fluid, generally invisible, which appears to be diffused through most bodies.

If a stick of sealing-wax or a watch-glass be rubbed upon a dry piece of woollen cloth, it will be found, while warm by the friction, that they have acquired the property of attracting small light bodies, as feathers, &c. Some of these will adhere to the surface of the wax or glass, and others will be thrown off from the body, as if they were repelled from it. This phenomenon may be strikingly exemplified by the small apparatus represented at fig. 1. A, is a stand with a bent wire, to which, at the hook, B, a fine silk thread is attached, having at its extremity a small pith ball, C. If the glass rod, D, be rubbed and presented to the ball, this will be immediately attracted to the glass, and will remain in contact with it for a few seconds; if the glass be now withdrawn, and again presented to the ball, the latter will be repelled (fig. 2). If, instead of the glass, a piece of sealing-wax, rubbed in the same way, be employed, the same effect is produced. Both these electrics have, therefore, in the first place, the power of *attracting* another body before they have communicated to it any of their own electricity; and, secondly, having communicated a portion of their electricity, they *repel* it. But a very remarkable circumstance takes place, if we, after having conveyed electricity to the ball, C, by means of excited glass, should present to it, after the former was withdrawn, excited sealing-wax: the ball, instead of being *repelled*, as it would be were the ball again applied, is *attracted* by the wax. If the experiment be reversed, and the excited wax first presented to the ball, and then the excited glass, the latter will be found to repel the ball. Hence, we conclude, that there are two opposite electricities; namely, that produced by excited glass, to which the name of *vitreous*, or *positive* electricity, has been given, and that produced by excited wax, to which the name of *resinous*, or *negative* electricity, has been given.

Fig. 3 represents the *Cylindrical Electrical Machine*, consisting of a hollow cylinder of polished glass, C C, revolving upon an axis. Two hollow metallic conductors, D E, are placed parallel to the cylinder on each side, upon two insulated pillars of glass. To one of these conductors, E, a cushion is attached, and held close to the cylinder; from the upper edge of the cushion there proceeds a flap of oiled silk, which extends over the upper surface of the cylinder to within an inch of a row of metallic points, proceeding from a hollow rod fixed to the side of the opposite conductor. When the cylinder is driven round by the handle, the friction of the cushion upon it produces a transfer of the electric fluid from the latter to the former; that is, the cushion becomes negatively, and the glass positively, electrified. By the revolution of the cylinder, the fluid adhering to the glass is carried round, and its escape prevented by the silk flap, until it arrives near to the metallic points, which absorb most of the electricity, and convey it to the prime conductor, D, which thus becomes positively electrified, while the other conductor, having parted with this electricity, is negatively electrified.

Fig. 4 represents the *Plate Electrical Machine*. The plate is turned by the handle through the rubber, which is coated with a metallic amalgam, and diffuses the excitement over the glass, the points carrying off a constant stream of positive electricity to the prime conductor, upon the principle already described.

Fig. 5 represents the *Hydro-Electric Machine*, an apparatus of recent date and construction, and of immense power. It consists of a steam boiler, A, insulated on stout glass pillars. The steam is made to issue through a great number of bent iron tubes, B B, terminating in jets of wood. An insulated projecting conductor, C, is placed in connexion with the boiler, for the purpose of collecting the excited electricity; and another conductor, D, formed of a metallic case having several rows of points, is placed immediately in front of the jets, to receive and carry off the opposite electricity of the steam, and prevent its return to the boiler, by which the excited forces would be neutralized. The electricity thus produced is the result of the friction of condensed particles of water, whilst being driven by the still issuing steam through the jets, these watery particles, performing the office of the glass plate, or cylinder of the common machine, and giving out vitreous electricity. The wood jets and pipes act as the rubber, and give out resinous electricity.

ELECTRICITY.

Electricity can be transferred or communicated from one body to another. An electrified ball can be deprived of its electricity by being touched with a metallic rod, but if we touch it with glass or wax the electricity will remain unaffected. Hence, metals are said to be *conductors*, and glass and wax *non-conductors*. Bodies differ greatly in their power of conduction. A list of the principal substances that possess these properties will be found on the diagram. The most convenient mode of obtaining an accumulation of electricity, is by employing a cylindrical glass jar, coated within and without nearly to the top with tin-foil, and having a cover of baked wood incased with sealing-wax to exclude moisture and dirt. A metallic rod rising above the jar, and terminating in a brass nob, is made to descend through the cover and communicate with the interior coating. An apparatus of this kind is called a *Leyden jar*, and is represented at fig. 6.

Fig. 7 represents a discharging rod, for establishing a communication between the inner and outer coating of the jar. The handle is of glass, to prevent the operator from receiving the charge of the jar.

By uniting a sufficient number of jars, we are able to accumulate a large amount of electricity. Such a combination of jars is called an *Electrical Battery*, (fig. 8).

Fig. 9 represents an instrument called a *Universal Discharger*, which is used for passing charges through any substance that may be laid on plate A.

Fig. 10 represents an *Electro-meter*, an instrument used to detect the presence of electricity. If charged, either by placing the instrument on one of the conductors of a machine, or on the rod of an electrical jar, the reed rises and marks as an index on the graduated semicircle the angle of divergence, by which the comparative amount of electrification may be estimated. The hairs upon the well-known electrical toy, represented at fig. 11, are spread out, and stand on end upon the same principle.

Fig. 12 represents two bells suspended from a brass wire, D D, supported by a glass pillar, A. The electricity being conducted to the knob E, passes down the wires, D D, to the bells, which are then *positively* electrified, and attract the clappers, C C, that are negatively so, in consequence of being insulated by silken strings. The clappers having become charged, strike against the centre bell to discharge themselves, and thus a peal is rung on the bells till the electricity is taken off.

Electric sparks are of a bluish colour in the atmosphere in its ordinary state, and their character depends almost entirely on the form, area, and electrical intensity of the discharging surfaces. If the small ball, P (fig. 13), be attached to the prime conductor of a machine, and a larger ball, N, be presented to it, a series of brilliant sparks, of a crooked or zigzag form, will pass from the smaller to the larger ball. When, however, electricity is given off from short points, it is unaccompanied by noise, and presents the brush-like appearance represented at fig. 14.

The influence of pointed conductors on electrically charged bodies, was first observed by Franklin, who showed that when presented to them, their charges became silently and rapidly dissipated. Hence, the utility of pointed conductors to secure buildings from the effects of lightning (fig. 15).

Galvanism.—The production of electricity in this case arises from the corroding action of an acid upon metallic surfaces. The acid being interposed between two plates of dissimilar metals, usually copper and zinc, and the zinc being the more oxidable, gives out positive electricity. The two plates are connected together at the top by a wire, and this communciation establishes what is called a voltaic or galvanic circuit; the electricity circulating round the zinc, wire, copper, and liquid (fig. 16).

There are many forms of galvanic batteries. Fig. 17, represents Daniell's battery, consisting of a cylinder of copper containing a porous tube, having a solid rod of amalgamated zinc in its centre. Fig. 18, represents Griffin's improved Smee's battery, consisting of six cells; the plates are arranged upon a frame suspended, by means of a rod and rocket wheel, over the trough containing the exciting liquid. By this arrangement any desired degree of power may be obtained by merely raising or depressing the frame.

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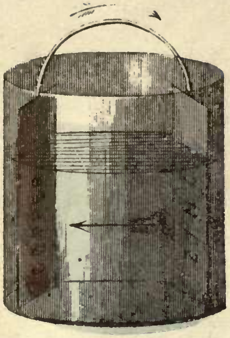

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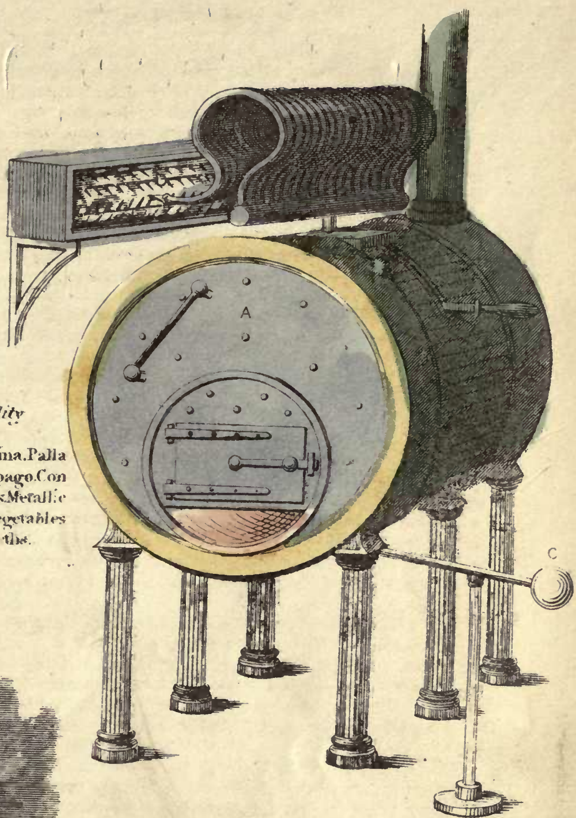

CONDUCTORS

Arranged in order of their Conductibility

Silver, Copper, Lead, Gold, Brass, Zinc, Tin, Platina, Palladium, Iron, & Metals in General, Charcoal, Plumbago, Concentrated-Acids, Diluted-Acids, Saline Solutions, Metallic Ores, Animal Fluids, Water, Living Animals & Vegetables Flame, Soluble Salts, Alcohol, Moist-Earths.

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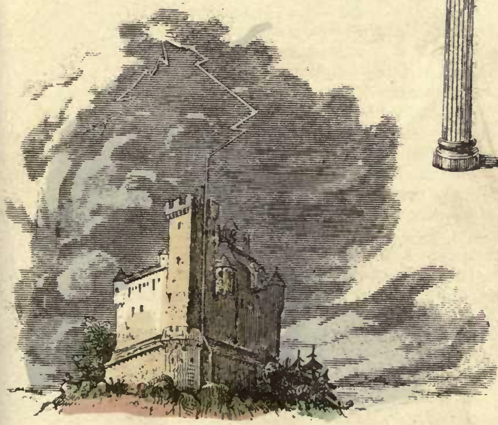

NON CONDUCTORS

Arranged in order of their non conductibility

Shell-lac, Amber, Resins, Sulphur, Wax, Glass, Various Minerals, Silk, Wool, Hair, Feathers, Leather, Air, & all Dry Gases, Baked Wood, Dry Vegetable Bodies, Porcelain, Camphor, Caoutchouc, Dry Chalk, Lime, Phosphorus, Ashes of Animal and Vegetable Bodies, Oils.

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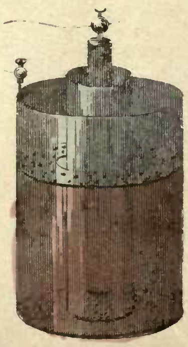

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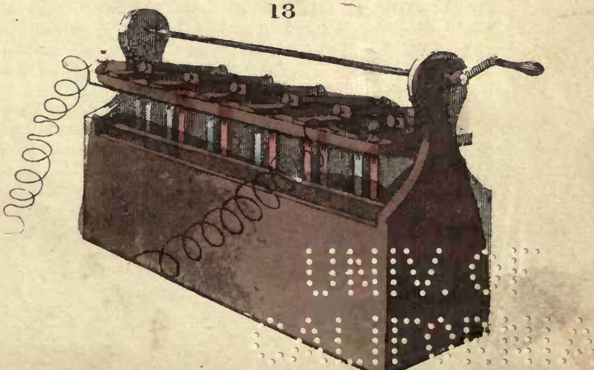

MAGNETISM

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MAGNETISM.

The theory of magnetism bears a very strong resemblance to that of electricity. Like it, magnetism has its attractions and repulsions, and it can be excited in one body and transferred to another, with, however, this striking peculiarity, that carbonized iron or steel, is nearly the only substance capable of exhibiting any strong indication of its presence. The *loadstone*, or natural magnet (fig. 1), is a hard, dark coloured mineral, found chiefly in iron mines; it is, however, seldom used, as its properties can be imparted to bars of steel, which may be made more powerful than itself.

Fig. 2 illustrates the polarity of the magnet. If a bar or needle, which has been rendered magnetic, be accurately poised on a point, one of its ends will point towards the north, and the other towards the south; hence, those parts of the magnet are termed the *north* and *south poles*.

The reciprocal attractions, repulsions, and neutralizations of the opposite magnetic forces may be illustrated by straining a piece of paper upon an open frame, and placing it over a bar magnet (N S, fig. 3). If some iron filings be now sifted upon the paper screen, the particles will arrange themselves in a series of curved lines, proceeding from similar points on each side of the middle of the bar; others will stand out at the extremities, as if repelled from the poles N S. If the *opposite* poles of two magnets be presented to each other, at about two inches distance, and iron dust be projected over them as before, similar results will ensue. Magnetic lines proceeding from similar points of each bar will appear uniting the two poles, as represented at fig. 4. If two *similar* poles be presented to each other, the lines of force mutually repelling each other, will present the appearance shown at fig. 5.

Fig. 6 represents the horse-shoe form of magnet, in which the two poles are brought near together, so as to attract a piece of iron by their combined force.

The earth itself is found to be a vast magnet, having its two magnetic poles situated in the neighbourhood of, but at some distance from, its poles of revolution. This is the reason why magnetized needles point in a north and south direction, not to the earth's axis (except at certain places), but to the magnetic poles. This will be seen by reference to fig. 7, which represents compass needles distributed over the globe, all lying in the direction of lines drawn from one magnetic pole to the other.

Fig. 8 represents the mariner's compass, the most essential part of which is a magnetized bar of steel, called the needle, accurately poised on a fine central point within a bowl or case, which is so supported as always to preserve a horizontal position. Upon the needle is placed the circular card represented at fig. 9, the ornamental point N being placed over the north pole of the needle, consequently the points round the circle indicate the cardinal and all intermediate points.

The inclination, or *dip* of the needle—that is, its deviation from the horizontal plane—affords a manifestation of the influence exercised upon it by the magnetism of the earth. Hence a dipping needle poised on a horizontal axis (as fig. 10). will, when carried to either of the earth's magnetic poles, stand *upright*, the end which is upward at one pole, being downward at the other. The further we recede from either pole, the less does the needle dip, as shown at fig. 11, where the dotted lines indicate the lines of equal dip, or parallels of *magnetic latitude*, and A and B, the north and south *magnetic* poles.

Electro Magnetism.—This department of science is founded on the connection ascertained to exist between electricity and magnetism. A (fig. 12) represents a bar of soft iron, bent into the horse-shoe form, around it is coiled a quantity of copper-wire covered with silk. The ends of the wire are connected with the poles of an active voltaic battery, the electricity from which passing along the coiled wire, converts the soft iron bar into a powerful *electro-magnet*, capable of sustaining, by its attractive force, a weight of many hundred pounds, and which it will continue to support so long as the connection with the battery is maintained, but the moment that connection is broken, the magnetic power of the iron ceases, and the weights fall.

The magnetic action circulates round the wire in two currents, moving in opposite directions, as represented at fig. 13. The wire being electric along its length and magnetic across.

Fig. 14, illustrates the action of electric currents upon a magnetic needle. A A, is a coil of copper wire, B, a magnetic needle freely poised, and pointing north and south. If the wire, C, be connected with the copper pole, and the wire, D, with the zinc pole, of an active voltaic battery, the needle will turn eastward, and upon reversing the wires, the needle will turn westward. Upon this simple principle depends the action of that astonishing apparatus the Electric Telegraph, of which our limits will only allow a brief description.

Fig. 15, represents a front view of the Telegraph instrument in which two needles are employed. Upon the dial plate are arranged certain letters, figures, and conventional signs. At the top of the instrument, within an ornamental case, is placed a bell or alarum to call attention to the instrument when a communication is about to be made. The alarum is put in action by a current of electricity being passed through a coil of wire encircling a piece of soft iron, which is thus converted into an electro-magnet, and attracts a lever, by which clock-work is set in motion, and the hammer caused to strike the alarum.

Fig. 16, represents the internal mechanism for moving each needle. The handle shown on the front of the instrument is attached to and works the cylinder A. This cylinder has its two ends capped with brass and insulated from each other by a belt of wood B; from the under part of one end projects a steel pin, C, and from the upper part of the other end, a similar pin, Z, these pins representing the copper and zinc poles of the battery with which they are in connection. In giving a signal, the handle is turned either to the right or left according to the direction the needle is required to take. Thus, by turning the cylinder so as to press the pin, Z, against the spring D, separating the latter from the point on the brass rod, E, the pin, C, is brought into contact with the boss, F. The electric current now passes from the pin, C, by the boss and metallic conductor through the wire coils, deflects the needle, and passing from the terminal, H, to the line wire it similarly deflects the needles of all the instruments in connection, and, being conducted at the extremity of the line to a plate of metal buried in the ground, it is transmitted by the earth to the terminal, G, and by the conductor and spring, D, to the pin Z. By reversing the movement of the cylinder the direction of the current is also reversed, and the needles are deflected in the opposite direction.

Magneto-Electricity.—As magnetism is derived from electricity, so electricity may be obtained from magnetism. If a piece of soft iron, A A, fig. 17, encircled by coils of copper wire be brought into, or removed from contact with the poles of a magnet, B B, electrical currents of a considerable magnitude are produced in the wire, and sparks will pass between the ends of the wire, P and N. To produce the effect, it is essential that the magnet be in motion, or that the conductor be in motion across the magnet.

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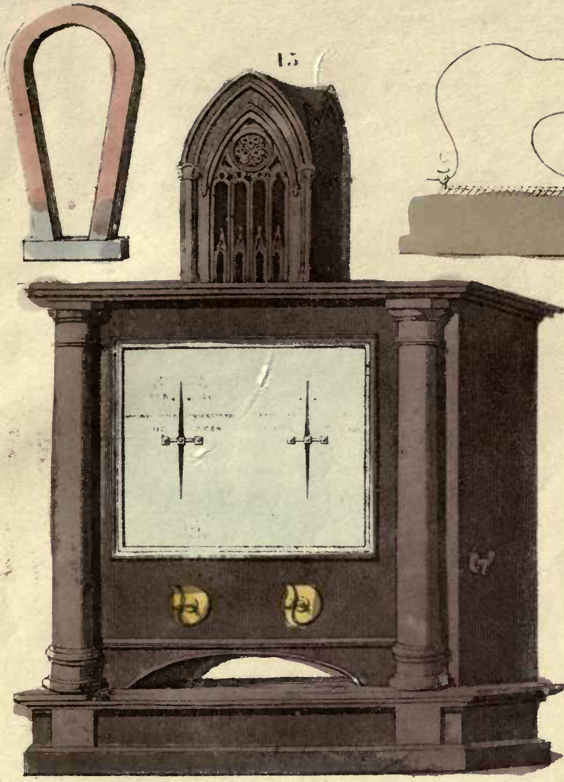

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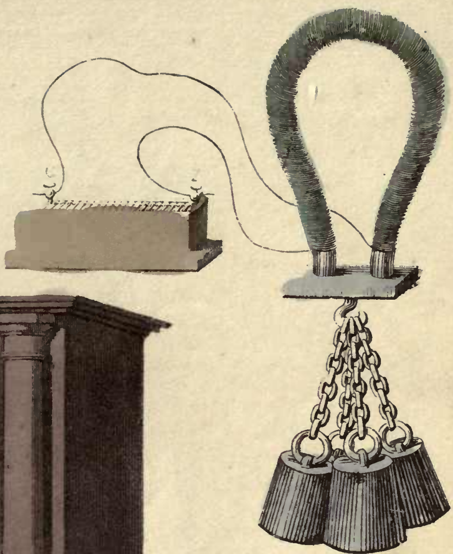

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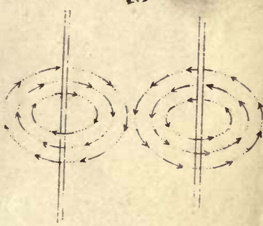

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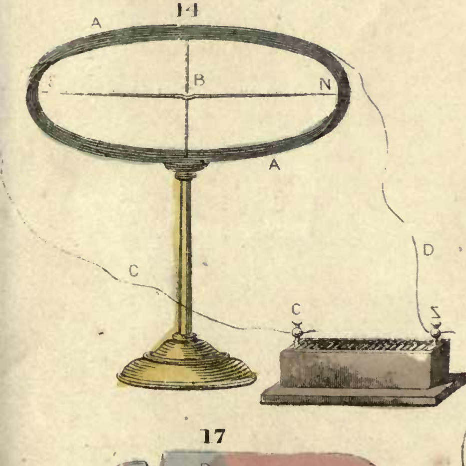

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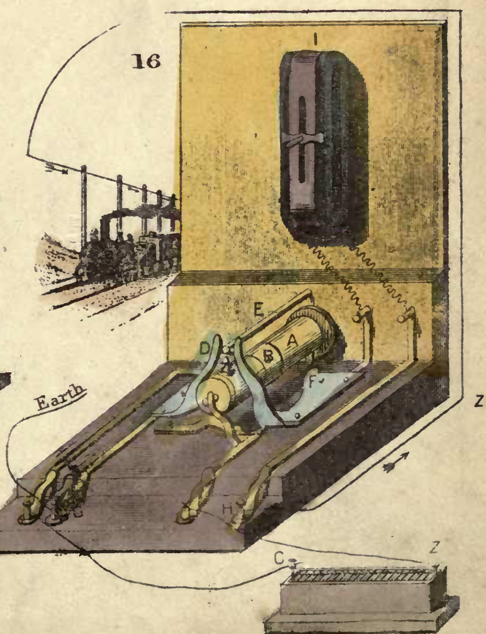

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