UNIVERSAL SCIENCE,

OR THE

CABINET OF NATURE AND ART.

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OR THE

CABINET OF NATURE AND ART:

COMPRISING ABOVE ONE THOUSAND

ENTERTAINING AND INSTRUCTIVE

FACTS AND EXPERIMENTS,

SELECTED FROM VARIOUS

DEPARTMENTS OF NATURAL PHILOSOPHY,

AND THE

USEFUL DISCOVERIES IN THE ARTS.

ILLUSTRATED BY NUMEROUS ENGRAVINGS ON WOOD.

IN TWO VOLUMES.

VOL. I.

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PREFACE.

THE object of these Volumes is to conduct the Student through a scientific course, in a safe and easy mean between the two extremes of turgid brevity on the one hand, and verbose digression on the other. And to accomplish this desirable end, a selection has been made of those branches of scientific knowledge, which presented the greatest variety of instructive facts, and popular experiments. But to blend amusement with instruction the fine arts have been resorted to, and the whole range of manufactures which have received improvements from modern discoveries in chemical science, has been ransacked to present to the reader whatever was curious and deserving attention. By the exclusion of irrelevant matter, the Author has been enabled to dwell more at length on subjects of greater interest, and to introduce many articles that have never been offered to youth in a popular and inviting form, as also of incorporating with the explanatory matter, such historical facts and anecdotes connected with the text as seemed most conducive to the reader's information and instruction. Yet new principles and new subjects of investigation are not to be looked for in a work which professes only to detail the discoveries and improvements of preceding writers, of machinists, of artificers, and manufacturers. For it is certainly more worthy the time and labour of youth to gain some knowledge of those arts and sciences with which they may become acquainted with a view to after life, than to harass them with exploded theories, and researches merely speculative. Guided by these views in the selection of his materials, the Author was enabled to give more latitude to his arrangements and classifications of the excellent models he had before him; and in no instance is he aware of having introduced any novelties at the risk of simplicity or the expense of truth: perspicuity and conciseness being as essential as variety of matter or accuracy of illustration.

Moreover, it has been his intention to render these volumes a source of useful and active entertainment to young persons, and at the same time that they opened their minds to enlarged views of nature and the universe, the true methods of reasoning in philosophy, and upon the powers of man, might be pointed out; thereby teaching them to distinguish what is sound and solid from what is hollow and vain; to lead youth on the verge of manhood from a consideration of the works of God to acknowledge and reverence his power, wisdom, and goodness.

The Author's aim has been, in the compilation of these volumes, to present to ingenious youth the most useful RECREATIONS in the ARTS and SCIENCES. This idea suggests at once that his "UNIVERSAL SCIENCE," ought to be considered as a PRESENTATION BOOK for youth who are somewhat advanced in their studies; and which may be advantageously put into their hands while finishing their education, or given away as a prize at school, or a Christmas present. In this light it may be conceived as adapted to either sex. Nor should its applicability be overlooked, to refresh the memory or instruct the mind of adults, who may have partially, or at an earlier period, studied the subjects of which it treats.

Conscious that his intentions have been sincere, and his motives pure, to advance science, to promote truth, happiness, order, and peace, the Author trusts to receive the approbation of those he has attempted to instruct, and the indulgence of those who are better judges than himself of Philosophy, Science, and the Arts.

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UNIVERSAL SCIENCE.

CHAPTER I.

GEOLOGY.

SECTION I.

INTRODUCTION.

GEOLOGY, (or Geognosy, as the Wernerian Mineralogists term this science) is the doctrine of the earth in its insentient or unorganized frame; and consequently comprehends its subterranean, superficial, and geological phenomena.

Obs. Of a portion of two of these parts we shall treat in the subsequent chapters: what we shall now investigate is purely geological.

Our object in this chapter, as every where else in this work, will be to present facts, to account for phenomena where the causes can be traced by induction, and where our want of information leaves room to doubt, there to stop; and with such evidence or data as we can furnish, leave the reader to form his own judgment. This appears a more natural and philosophical method of pursuing scientific studies, than the invention of theories, and the crudity of speculations, the bare announcement of facts, and the churlish pride of disdaining to give an opinion on those facts.

In this view, therefore, the division of our subject being made, the first chapter shall be as brief as its nature will admit, but the second shall contain all the information that has novelty to recommend it to the reader; nor will any fear of prolixity hinder us from exhibiting the most ample display of the phenomena of nature, which the science of Geology presents. Instruction will thus be blended with amusement, and the acquisition of scientific knowledge be rendered a pastime, not a task.

SECTION II.

ROCKS AND VEINS.

1. THE stony masses of which the earth is composed, are numerous, and are found laid one above another; so that a rock of one kind of stone is covered by another species of rock, and this by a third, and so on. In this superposition of rocks, it has been observed, that their situation is by no means arbitrary; each occupies a determinate place, so that they follow one another in regular order from the deepest part of the earth's crust which has been examined, to the very surface.

Thus there are two things respecting rocks which claim our attention; namely, their composition, and their relative situation. But besides the rocks which constitute almost the whole of the earth's crust, there are masses to be considered traversing the rocks in a different direction, and known by the name of *veins*, as if the rocks had split asunder in different places from top to bottom, and the chasm had been afterwards filled up with the matter which constitutes the vein.

Thus it appears, that the subject naturally divides itself into three parts; 1. The structure of rocks; 2. The situation of rocks; 3. Veins; and these shall form the subject of the three following sections.

SECTION III.

OF THE STRUCTURE OF ROCKS.

2. Rocks may be divided into two classes; viz.

I. Simple, or *composed of one mineral substance.*

II. Compound, or, *composed of more than one mineral substance.*

I. Cemented; composed of grains agglutinated by a cement, as *sand-stone.*
II. Aggregated; composed of parts connected together without a cement, as *granite.*

The aggregated rocks are likewise of two kinds; namely,

I. Indeterminate.

Only one instance of this kind of aggregation has hitherto occurred, namely, in the *older serpentine*, where lime-stone and serpentine are so conjoined, that it is difficult to say which predominates.

II. Determinate.

The determinate are either, I. Single aggregated; or, II. Double aggregated.

There are four kinds of single aggregated rocks; namely,

1. Granular; composed of grains whose length, breadth, and thickness are nearly alike, and which are of contemporaneous formation. As *granite, sienite.*
2. Slaty; composed of plates laid above each other; as *mica slate.*
3. Porphyritic; composed of a compact ground, containing in it crystals, which appear to have been deposited at the time the rock was formed; as *common porphyry.*
4. Amygdaloidal; composed of a compact ground, containing in it vesicles which appear to have been afterwards filled up; as *amygdaloid.*

There are five kinds of double aggregated rocks; namely,

1. Granular slaty: composed of slaty masses laid on each other. Every individual slate is composed of grains cohering together; or it is slaty in the great, and granular in the small; as *gneiss.*
2. Slaty granular; composed of large granular masses cohering together; each grain is composed of plates; or the rock is granular in the great, and slaty in the small; as *topaz rock.*
3. Granular porphyritic; granular in the small, and porphyritic in the great; as *granite, green-stone* frequently.

4. Slaty porphyritic; slaty in the small, porphyritic in the great; as *mica slate* frequently.

5. Porphyritic and amygdaloidal; a mass porphyritic and amygdaloidal at the same time; as *amygdaloid* and *basalt* frequently.

SECTION IV.

OF THE RELATIVE SITUATION OF ROCKS.

3. THE rocky masses, amount to about sixty. Of these rocks, variously placed over each other, the whole crust of the earth is composed, and with respect to each other, they usually occupy a determinate situation, which holds invariably in every part of the earth. Thus lime-stone is no where found under granite, but always above it.

Were we to suppose every particular rock, or layer, which constitutes a part of the earth's surface to be extended round the whole earth, like the coat of an onion, in that case every rock would be constantly found; one species would be always lowest or nearest the centre; another would uniformly rest upon this first; a third upon the second, and so on. Now, though the rocks do not in reality extend round the earth in this uninterrupted manner, we can trace enough to convince us that the rocks which constitute the earth's crust, considered in a great scale, are every where the same, and that they invariably occupy the same situation with respect to each other. Werner has therefore chosen this relative situation as the basis of his classification of rocks. He divides them into five classes.

The first class consists of those rocks which, if we were to suppose each layer to be extended over the whole earth, would in that case lie lowest, or nearest the centre of all the rocks which we know to be covered by all the other rocks.

The second class consists of those rocks which in that case would be immediately above the first class and cover them.

The third class would cover the second in the same manner; the fourth the third; and the fifth would be uppermost of all, and constitute the immediate surface of the earth. The first class of rocks are covered by all the rest, but never themselves lie over any other. The others lie in order over each other.

These grand classes of rocks he has denominated *formations,* and distinguished them by the following specificn ames:

I. Primitive formations.
II. Transition formations.
III. Floetz, or horizontal formations.
IV. Alluvial formations.
V. Volcanic formations.

The primitive formations are the lowest of all, and the alluvial constitute the surface of the earth; for the volcanic are confined to particular points. Not that the primitive are always at a great depth, for very often they are at the surface, or even constitute mountains. In such cases, the other formations are wanting altogether. In like manner the transition, and other classes, may each in its turn occupy the surface, or constitute the mass of a mountain. In such cases, all the subsequent formations are wanting in that particular spot.

Each of these grand classes of formations consists of a great or small number of rocks, which occupy a determinate position with respect to each other, and which, like the great formations themselves, may often be wanting in particular places.

4. Class I. *Primitive Formations.* The rocks which constitute the primitive formations are numerous, and have been divided into seven sets, which constitute as many primitive formations. They are distinguished each by the name of that particular rock which constitutes the greatest proportion of the formation. And these seven sets of primitive formations are the following:

1. Granite
2. Gneiss
3. Mica-slate
4. Clay-slate
5. Newest primitive porphyry
6. Sienite
7. Newer serpentine.

The granite is the undermost, the sienite the uppermost of the primitive formations. Granite is scarcely mixed with any other rock; but in gneiss, mica-slate, and clay-slate, there occur beds* of old porphyry, primitive trap, primitive lime-stone, old serpentine, quartz rock. For that reason these rocks are said to constitute formations subordinate to gneiss, mica-slate, and clay-slate. Gypsum occurs in beds in mica-slate, and old flint-slate occurs in the same way in clay-slate. Hence they constitute formations subordinate to mica and clay-slate.

Thus, besides the seven principal primitive formations, there occur seven subordinate formations, interspersed through the second, third, and fourth formations; and topaz rock, which lies over gneiss and under clay-slate, must be added to the list: so that the primitive formations altogether amount to fifteen.

If we suppose the nucleus of the earth to have been first formed, and the formations to have been afterwards successively deposited upon this nucleus, the lowest formation is the oldest, and then the formations are newer and newer according as they rise to the surface.

This supposition accounts for some of the names given to the primitive formations. That porphyry, for example, is considered as the oldest, which lies lowest in the series, and those formations of porphyry which rise nearer the surface are newer. Granite is, therefore, the oldest, while the alluvial are the newest formations.

5. Class II. *Transition Formations.* These lie immediately over the primitive formations. They are by no means so numerous as the first, since they consist only of four sets; namely,

1. Grey wacke.
2. Transition lime-stone.
3. Transition trap.
4. Transition flint-slate.

They all alternate with each other, sometimes one, sometimes another being undermost, except one bed of transition lime-stone, which seems to rest upon the primitive formations, and may be considered as the oldest of the transition formations.

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* When a mountain is composed of layers of the same kind of stone, it is said to be stratified; but when the layers are of different kinds of stone, it is said to be composed of beds.

It is in the transition rocks that petrifactions first make their appearance; and they always consist of species of corals and zoophytes, which do not at present exist, and which therefore we may suppose extinct. The vegetable petrifactions are likewise the lowest in that kingdom, such as ferns, &c.

This remarkable circumstance has induced Werner to conclude, that the transition rocks were formed after the earth contained organic beings.

Hence the name *transition*, which he has imposed, as if they had been formed when the earth was passing from an uninhabited to an inhabited state. The date of their formation is conceived to be very remote, since the petrifactions which they contain are the remains of animal and vegetable species now extinct. It is in the transition rocks, too, that carbonaceous matter makes its first appearance in any assignable quantity.

6. Class III. *Floetz Formations*. The next grand class of formations has received the name of *floetz*, because they lie usually in beds much more nearly horizontal than the preceding.

When not covered by a succeeding formation, they form hills which do not rise to the same height as the primitive or transition. They contain petrifactions more various in their nature than those which occur in the transition formations, and consist of shells, fish, plants, &c. indicating that they were formed at a period when organised beings abounded.

The floetz formations lie immediately over the transition. They comprehend a great number of individual formations, each of which affects a particular situation. The following table exhibits a view of these different formations in the order of their position, as far as is known.

1. Old red sand-stone
2. First floetz lime-stone
3. First floetz gypsum with rock-salt
4. Variegated sand-stone
5. Second floetz gypsum
6. Second floetz or shell lime-stone

7. Third sand-stone or free-stone
8. Chalk
9. Independent coal
10. Floetz trap.

The floetz trap formation lies over the rest, pretty much as the newer porphyry and sienite do over the older primitive formations.

Class IV. *Alluvial Formations.* The alluvial formations constitute the great mass of what is actually the earth's surface. They have been formed by the gradual action of rain and river water upon the other formations, and may be considered as very recent formations, or rather as deposites, the formation of which is still constantly going on. They may be divided into two kinds: those deposited in the valleys of mountainous districts, or upon the elevated plains which often occur in mountains; and those deposited upon flat land.

The first kind consist of sand, gravel, &c. which constituted the more solid parts of the neighbouring mountains, and which remained when the less solid parts were washed away. They sometimes contain ores (particularly gold and tin) which existed in the neighbouring mountains. Sometimes the alluvial soil is washed, in order to separate these ores. On mountain-plains beds of loam are found.

The second kind of alluvial deposit, or that which occupies the flat land, consists of loam, clay, sand, turf, and calctuff*. Here also occur earth and brown coal (in this mineral amber is found), wood coal, bituminous wood, and bog iron-ore. The sand contains some metals, among others gold. The calctuff is a chemical deposit and extends widely. It contains plants, roots, moss, bones, &c. which it has encrusted. The clay and sand often contain petrified wood, and likewise skeletons of quadrupeds.

Class V. *Volcanic Formations.* The volcanic formations are of two kinds; namely, the *pseudo-volcanic* and the *true volcanic.*

The pseudo-volcanic consist of minerals altered in consequence of the burning of beds of coal si-

* Stalactic or calcareous tufa.

tuated in their neighbourhood. Porcelain jasper, earth slag, burnt clay, columnar clay-iron-stone, and perhaps also polishing slate, are the minerals which have been thus altered.

The real volcanic minerals are those which have been thrown out of the crater of a volcano. They are of three kinds:

1. Those substances which, having been thrown out from time to time, have formed the crater of the mountain.
2. Those which have been thrown out of the crater in a stream, and rolled down the mountain; they constitute lavas.
3. The water which is occasionally thrown out of volcanoes, containing ashes and other light substances gradually evaporating, leaves the earthy matter behind it; this substance constitutes volcanic tuff.

SECTION V.

OF VEINS.

7. Veins are mineral repositories which cut through the strata of which a mountain is composed, and which are filled with substances different from the rocks through which they pass. If we suppose that the mountains in which veins occur were split by some means or other, and that the rifts thus formed were filled up by the matter which constitutes veins, we shall have a clear notion of these mineral repositories, and which are distinguished from beds by their direction, it being either perpendicular to the stratifications, or at least in an angle with it.

Sometimes the strata through which veins pass are merely separated from each other; so that if we cut through the vein we find the same strata of the rock on both sides of it: but sometimes also the corresponding strata on one side are lower than on the other, as if the portion of the rock on one side of the vein had sunk a little, while the portion on the other side kept its original position. In such cases, the side of the rock against which the vein leans, or the floor of the vein, has always its strata highest up; whilst the strata of the portion of rock which leans over the veins, or the roof of the vein, are always lowest. So that this is the portion which appears to have sunk. Such a change of position in the strata is known in this country by the name of a *shift*.

In considering veins, there are two circumstances which claim our attention: namely, 1*st*. The shape of veins; and, 2*dly*. The substances with which they are filled.

1. All those mineralogists who have had the best opportunity of examining the shape of veins with correctness, represent them as widest above, and diminishing in size as they deepen, till at last they terminate in a point, as if they had been originally fissures.

Sometimes indeed, veins widen in different parts of their course, and afterwards contract again to their former size; but more commonly they continue diminishing to their extremity.

2. Sometimes these veins are either partially or entirely empty. In that case they are denominated *fissures*; but most commonly they are filled with a matter more or less different from the rock through which they pass. Sometimes the vein is filled up with one species of mineral.

Thus we have veins of calcareous spar, of quartz, &c.; but when a vein is of any size, we usually meet with a variety of substances: these are disposed in regular layers always parallel to the sides of the vein, and they follow in their position a very regular order. One species of mineral constitutes the centre of the vein: on each side of this central bed the same layers occur in the same order from the centre to the side of the vein. To give an example; the vein Gregorius, at Freyberg, is composed of nine layers or beds. The middle of the vein consists of a layer of calcareous spar; on each side of this is a layer consisting of various ores of silver mixed together; on each side of this a layer of brown spar; on each side of this a layer of galena; on each side of this again, and contiguous to the side of the vein, is a layer of quartz.

The following diagram will give the reader some notion of the relative position of these layers:

Gneiss rock.	Quartz	Galena	Brown spar	Silver ore	Calcareous spar	Silver ore	Brown spar	Galena	Quartz	Gneiss rock.

Sometimes the number of layers of which a vein is composed greatly exceeds this. Werner describes one in the district of Freyberg, in which the middle layer is calcareous spar, having on each side of it no less than thirteen layers arranged in the very same order.

Almost all the mineral substances which occur in the mass of rocks have been found in veins. We sometimes find them filled with different well known stoney bodies, as, granite, porphyry, lime-stone, basalt, wacke, green-stone, &c.; veins of quartz, clay, felspar, &c. are equally common.

Pit-coal and common salt, and almost all the metals, likewise occur in veins. Some veins are filled with water-worn pebbles, others with loam; sometimes with petrifactions.

In a calcareous mountain in Thuringia, there occur veins of marle five or six inches thick, containing petrifactions differing altogether from those which are found in the lime-stone. The petrifactions found in the marle are, cornua ammonis, terebrates, and turbinites; those in the lime-stone rock are trochites. Beds of the marle occur in the neighbourhood, and contain the same petrifactions as the veins.

It is common to find veins crossing each other in the same rock. When that happens, one of the veins may be traced passing through the other without any interruption, and cutting in two, while the other always separates, and disappears at the point of crossing.

Conclusion.—Such is a short sketch of the most remarkable phenomena respecting veins. Werner supposes that they were originally fissures formed in the rocks, and that they were all gradually filled by minerals deposited slowly from above, while the rocks in which they occur were covered by water, and that they were filled at the same time that the different formations were deposited.

This theory he has supported in his book on Veins, by a very complete enumeration of all the circumstances respecting their structure and appearances. He has shown that they resemble fissures very exactly in their shape and direction; and that as they contain petrifactions and minerals altered by the action of water, they must of necessity have been filled from above.

Veins of course, according to this theory, are newer than the rocks in which they occur; and when two veins cross, that is obviously the newest which traverses the other without interruption, as the fissures constituting the second vein must have been formed after the first vein was filled up.

When different veins contain the same minerals arranged in the same order, he conceives that they were filled at the same time, and says that such veins belong to the same formation. When they differ in these respects, they belong to different formations. From the position of the respective veins with respect to each other, he deduces their relative age; and from this draws inferences respecting the relative age of the different mineral substances that occur in veins similar to the inferences drawn respecting the age of the rocks which constitute the grand classes of formations.

Obs. The science of geology, independently of the healthy employment it affords, is of great importance in a practical point of view. It very nearly concerns the miner, engineer, and drainer, and even the farmer and architect; and discloses a variety of indications highly useful in their respective pursuits: to the miner, the rocks containing metallic veins and coals; to the engineer, the association of hard rocks with soft; to the drainer, the intersection of a country by hard dykes, or veins impermeable to water; to the farmer, the best places for finding lime-stone, marle, and clay; and to the architect, the most durable stones for buildings.

CHAPTER II.

GEOLOGICAL PHENOMENA.

SECTION I.

VOLCANOES AND EARTHQUAKES.

8. AMONG the varied geological phenomena that we shall enumerate, volcanoes and earthquakes claim the first place, for certainly there is no spectacle grander than an active volcano, and nothing more terrific than the shock of an earthquake; but when it is recollected that the agent chiefly employed in the production of either is subterranean fire, pent up by a huge mass of super-incumbent pressure, but powerful enough, under certain circumstances, to force its way through the solid crust of the globe, and enlighten it from the summit of a mountain, or make it reel to its centre by the thunder of an earthquake, the examination of the causes of these surprising phenomena, and their illustration by the relation of some facts cannot be uninteresting or uninstructive.

But though earthquakes and volcanoes may be results of chemical changes going on in the earth, their causes have probably some connexion with electricity, else why is the shock of an earthquake transmitted from place to place? For though we attribute the rapid succession of the effects to the operation of a single cause, acting like subterranean heat, at a great distance below the earth's surface; there are, however, some circumstances which indicate such a connexion between the state of the atmosphere and the approach of an earthquake, as cannot easily be explained by any hypothesis.

The shocks of earthquakes, and the eruptions of volcanoes, are in all probability modifications of the effects of one common cause; the same countries are liable to both of them; and where the agitation produced by an earthquake extends further than there is any reason to suspect a subterraneous commotion, it is probably propagated through the earth nearly in the same manner as a noise is conveyed through the air.

Volcanoes are found in almost all parts of the world, but most commonly in the neighbourhood of the sea; and especially in small islands; for instance, in Italy, Sicily, Iceland, Japan, the Caribbees, the Cape Verd islands, the Canaries, and the Azores: there are also numerous volcanoes in Mexico and Peru, especially Pichincha and Cotopaxi. The subterraneous fires, which are continually kept up in an open volcano, depend perhaps, in general, on sulphureous combinations and decompositions, like the heating of a heap of wet pyrites, or the union of sulphur and iron filings: but in other cases they may perhaps approach more nearly to the nature of common fires. A mountain of coal has been burning in Siberia for almost a century, and must probably have undermined in some degree the neighbouring country. The immediate cause of an eruption appears to be very frequently an admission of water from the sea, or from subterraneous reservoirs; it has often happened that boiling water has been discharged in great quantities from a volcano; and the force of steam is perhaps more adequate to the production of violent explosions, than any other power in nature. The consequence of such an admission of water, into an immense collection of ignited materials, may in some measure be unstood, from the accidents which occasionally happen in founderies: thus a whole furnace of melted iron was a few years ago dissipated into the air in Colebrook Dale, by the effect of a flood which suddenly overflowed it.

The phenomena of earthquakes and volcanoes are amply illustrated by the particular accounts, transmitted to the Royal Society by Sir William Hamilton, of those which have happened at different times in Italy. The earthquake, which desolated Calabria, in 1783, was fatal to about 40,000 persons, continuing its ravages for more than three months:

it destroyed the towns and villages occupying a circle of nearly 50 miles in diameter, lying between 38 and 39 degrees latitude, and extending almost from the western to the eastern coast of the southernmost point of Italy, besides doing considerable damage to places at much greater distances from its origin, which is supposed to have been either immediately under the town of Oppido, in the centre of this circle; or under some part of the sea, between the west of Italy, and the volcanic island of Stromboli.

This island, as well as Mount Etna, had smoked less than usual before the earthquake, but they both exhibited appearances of an eruption during its continuance; Etna towards the beginning, and Stromboli at the end. Before each shock the clouds were usually motionless for a certain time, and it rained violently; frequently also lightning and sudden gusts of wind accompanied the rain. The principal shocks appeared to consist in a sudden elevation of the ground to a considerable height, which was propagated somewhat like a wave, from west to east: besides this, the ground had also a horizontal motion backwards and forwards, and in some measure in a circular direction. This motion was accompanied by a loud noise; it continued in one instance for ten seconds without intermission: and it shook the trees so violently that their heads nearly reached the ground. It affected the plains more strongly than the hills. In some places luminous exhalations, which Sir William Hamilton thinks rather electrical than igneous, were emitted by the earth; the sea boiled up near Messina, and was agitated as if by a copious discharge of vapours from its bottom; and in several places, water, mixed with sand, was thrown up to a considerable height. The most general effect of these violent commotions was the destruction of buildings of all kinds, except the light barracks of wood or of reeds, into which the inhabitants retreated as soon as they were aware of their danger: the beds of rivers were often left dry, while the shock lasted, and the water on its return overflowed their banks; springs were sometimes dried up, and new ones broke out in other places. The hills which formed the sides of steep vallies were often divided by deep chasms parallel to the vallies; and in many cases large portions of them were separated, and removed by the temporary deluge to places half a mile or a mile off; with the buildings and trees still standing on them; and in this manner hills were levelled, and vallies were filled up.

But the most fatal accident of this kind happened at Scilla, where so large a portion of a cliff was thrown into the sea, that it raised an immense wave, which carried off more than 2000 inhabitants who were collected on the beach, and even extended its formidable effects to the opposite coast of Sicily, where several persons perished by it in a similar manner.

The eruptions of volcanoes are usually attended by some shocks like those of earthquakes, although commonly less violent. Open volcanoes continually throw out in more or less abundance, smoke, ashes, and pumice stones, or light cinders; but their most formidable effects are produced by a torrent of ignited lava, which, like a vast deluge of liquid or semi-liquid fire, lays waste the country over which it runs, and buries all the works of human art.

In March, 1767, Vesuvius began to throw out a considerable quantity of ashes and stones, which raised its summit in the course of the year no less than 200 feet, forming first a little mountain of pumice stones within the crater, which by degrees became visible above its margin. The smoke, which was continually emitted, was rendered luminous at night, by the light derived from the fire burning below it. In August some lava had broken through this mountain, and in September it had filled the space left between it and the former crater. On the 13th and 14th of October there were heavy rains, which perhaps supplied the water concerned in the eruption that shortly followed. On the morning of the 19th, clouds of smoke were forced, in continual succession, out of the mouth of the volcano, forming a mass like a large pine tree, which was lengthened into an arch, and extended to the island of Caprea, 28 miles off; it was accompanied by much lightning, and by an appearance of meteors like shooting stars. A mouth then opened below the crater, and discharged a stream of lava, which Sir William Hamilton ventured to approach within a short distance, imagining that the violence of the confined materials must have been exhausted; but on a sudden the mountain opened with a great noise at a much lower point, about a quarter of a mile from the place where he stood, and threw out a torrent of lava, which advanced straight towards him, while he was involved in a shower of small pumice stones and ashes, and in a cloud of smoke. The force of the explosions was so great, that doors and windows were thrown open by them at the distance of several miles: the stream of lava was in some places two miles broad, and sixty or seventy feet deep; it extended about six miles from the summit of the mountain, and remained hot for several weeks. In 1794 a still more violent eruption occurred: it was expected by the inhabitants of the neighbourhood, the crater being nearly filled, and the water in the wells having subsided. Showers of immense stones were projected to a great height; and ashes were thrown out so copiously, that they were very thick at Taranto, 250 miles off; some of them also were wet with salt water. A heavy noxious vapour, supposed to be carbonic acid, issued in many places from the earth, and destroyed the vineyards in which it was suffered to remain stagnant. A part of the town of Torre del Greco was overwhelmed by a stream of lava, which ran through it into the sea; yet, notwithstanding the frequency of such accidents, the inhabitants had so strong a predilection for their native spot, that they refused the offer of a safer situation for rebuilding their houses.

Can the poor, brittle tenements of man
Withstand the dread convulsion? Their dear homes,
(With shaking, tottering, crashing, bursting, fall,)
The boldest fly; and on the open plain,
Appall'd, in agony, the moment wait,
When, with disrupture vast, the waving earth
Shall 'whelm them in her sea-disgorging womb.
Nor less affrighted, are the bestial kind:—
The bold steed quivers in each panting vein,
And staggers, bath'd in deluges of sweat:—
The lowing herds forsake their grassy food,
And send forth frighted, woful, hollow sounds:—
The dog, the trusty centinel of night,
Deserts his post assign'd, and piteous howls.

THOMSON.

Eruption of Mount Vesuvius in 1817.

9. Of this eruption, Signor Monticello gives the following account. It began on the 22d, and terminated on the 26th of December. On the 23rd, I was at Resina, and on the 24th at Torre del' Annunciata; so that I had an opportunity of observing the two currents of lava, one of which ran towards the plain of Pedimentina, the other towards Mauro.

On the 24th, I remarked that the small conical hillock which stood near the centre of the edge of the crater had disappeared; it seemed swallowed up by the same ignivomous aperture which raised it in 1816. The other smaller hillock upon the western ridge of the crater had also fallen in, and was swallowed up by a very large rent upon that side of the volcano. Instead of these hillocks, I found the recent lava curiously disposed in the manner of a wall, fortifying, as it were, the ancient crater upon the east and west sides; convex, and very irregular upon the north and south. Of this wall some parts are quite even and regular, looking exactly like our terraces: the whole was extremely hot, and apparently incandescent in the interior, as seen through some of the holes and fissures. I have little doubt that parts of these walls were hollow, not only from this appearance, but from the sound occasioned by throwing a large stone upon any part of them. Upon the south, all former appearances are destroyed, and there has been produced a very gently-inclined plain, covered with fine sand; indeed it would have been impossible here to have recognized the former edge of the crater, were it not for two large blocks of stone which were thrown up in the eruption of 1812, and which, though much changed by the action of two small *fumarolee* underneath them, have burned since the year 1815, and still serve as landmarks. This plain is often traversed by long fissures, more or less perpendicular, running east and west.

On the 2d of March we counted round the crater fourteen apertures, most of which were still smoaking; one of them was circular, and about two feet in diameter; it was perfectly quiet, and appeared of an unfathomable depth.

The largest of them is on the northern side of the crater, at a little distance from the great fissure which rent the cone asunder during the eruption of 1813, and which has been entirely obliterated, or at least covered by the late formation of lava. Upon the north-east side, a little above the sandy plain, is the new crater, which poured forth the lava that cut the cone of the volcano, and took the direction of Mauro. This lava spread round the ancient Somma, and upon the east side of that mountain descended through a wood, and, passing before a house belonging to the Prince of Ottiana, reached to within a very short distance of the principal street of Mauro. On the 26th of December, while we were observing the progress of the torrent from a small wood of oaks near the Prince's Casino, we were suddenly surprised and alarmed by the motion of the ground we were standing upon, and, immediately afterwards, three small jets of flame made their appearance at a few feet only from us; we therefore hurried away to a place of safety, expecting a repetition of the same phenomenon, but we only observed jets of smoke here and there in the wood.

Whilst observing Vesuvius on the 24th of December, I remarked lava flowing from five apertures, which augmented the current that formerly issued from the south side of the cone previous to the destruction of Tòrre del Greco, and in which were small apertures emitting flame, and rapidly appearing and disappearing in succession. The light was very intense and splendid.

On the north of the great fissure of the crater above alluded to, the recent lava assumed the aspect of basaltic columns.

On the 27th of December, a cavern near Mauro was covered with a white incrustation of salt, sublimed from below; its quantity was so considerable, that fifty or sixty people made a profitable occupation by collecting it; for this purpose they either broke the stones, or scraped off the saline matter, and replaced them in their former situations, and a day or two afterwards they became again covered as before.

We often saw the deposition of this sublimate, which I am induced to believe required the presence of air for its formation, for it only existed near the surface, or in cavities open to the access of atmospheric air. The same observation applies to the beautiful specimens of sublimed oxide of iron (*fer obligiste*). Various other sublimates were deposited upon the lava, but in much smaller quantity; their colours were chiefly yellow, red, and green: they were most abundant near the large crater; the yellow and red were deliquescent; but the yellow and green permanent. The smell of muriatic acid, though frequently perceived near the large burning orifice of the mountain, was never observed in the lava of Mauro.

In the following letter on the destruction of Herculaneum and Pompeii, the reader is presented with a fine account of that grand eruption of Vesuvius which destroyed those cities.

My dear young Friend,

Perhaps, from having witnessed the late awful and destructive eruption of Mount Vesuvius, you will feel interested in a slight retrospection of a story the most celebrated upon record.

The earliest and most fatal eruption of Vesuvius, that is mentioned in history, is that which occurred A.D. 79, in the first year of the reign of Titus, and which is so ably described in Pliny's letter to Tacitus, that I need only refer you to that; for any attempt to shorten his exquisite account, would indeed be an unpardonable presumption. I shall, however, say thus much upon the subject.

The whole of Campania felt the effects of this eruption; many towns were completely destroyed, among which Herculaneum and Pompeii were the most conspicuous. Pompeii had suffered much from an earthquake sixteen years previous to this overwhelming calamity, but it had been rebuilt and adorned with many stately edifices. A superb theatre was just finished, and a numerous crowd of spectators was assembled within its spacious walls, when their city was suddenly swallowed up by an earthquake, and every trace of it vanished, for its disappearance was followed by such a deluge of lava, that the exact site of this devoted city remained unknown during sixteen centuries, at the end of which period it was discovered by chance in the year 1739.

The cities of Puteoli and Cannæ were also greatly damaged, partly by the earthquake, and partly by the burning ashes, which it is said extended to Africa, Egypt, and Syria. Besides Pliny the elder, who was suffocated, history has preserved among the names of the celebrated victims, the poet Cesius Bassus, who with all his household was consumed by the flames; and Agrippa, son of Claudius Felix, the well-known governor of Judea; and Drusilla, daughter to Agrippa the last king of the Jews, found an early grave in the ruins of Herculaneum. The next eruption upon record is that which formed the *Monte Nuovo* which we visited a short time since. This took place in the year 1538. The years 1631 and 1707 were marked by these awful visitations; but the last century has been most fatally marked by the violent eruptions of Vesuvius. That of the year 1799 was the most destructive that had taken place since the time of Pliny, and of which the following is a correct statement, copied from a MS. in our library, and which was written by an eye-witness of this frightful eruption. The mountain had been remarkably quiet for seven months previous to the eruption I am about to describe, nor did the usual smoke issue from its crater, but at times it emitted small clouds of smoke that floated in the air like little trees. A thick vapour was also seen to surround the mountain about a quarter of a mile beneath its crater; and the sun and moon had both an unusual reddish cast.

The water of the great fountain at Torre del Greco began to decrease some days before the eruption, so that the wheels of a corn-mill worked by water, moved very slowly, and many of the wells in the town became partially, and some quite dry. About eight days before the grand eruption, a man and some boys being in a vineyard above Torre del Greco, and precisely on the spot where one of the new mouths opened from the current of lava that overwhelmed that unfortunate town, were much alarmed by a puff of smoke, which came out of the earth, accompanied by a slight explosion; subterraneous noises were heard at Resina; yet all these symptoms passed unnoticed, and on Sunday, 13th of June, after a slight earthquake, a fountain of bright fire, attended with a very black smoke and a loud report, was seen gradually to issue, and rise to a great height, from about the middle of Vesuvius; another of the same kind soon afterwards broke out at some little distance lower down. From the terrific noise which accompanied this explosion, it appeared as if a covered channel full of red hot lava had blown up. Fresh fountains succeeded one another rapidly, and all in a direct line, dividing for about a mile and a half down, towards the towns of Resina and Torre del Greco. It is impossible that any description can give an idea of this fiery scene or of the horrid noises which attended this great operation of nature. It was a mixture of the loudest thunder with incessant reports, like those from a numerous heavy artillery, accompanied by a continued hollow murmur, which might be compared to the roaring of the ocean during a violent storm: in addition to this extraordinary combination of noises, a mighty rushing of the winds from every point of the compass with incredible fury, produced that thrilling awe which always accompanies the action of an invisible agent. The frequent falling of the large stones and scoriæ, which were thrown up to an incredible height from some of the new mouths, and one of which was afterwards measured by the Abbé Fata, and found to be ten feet high, and thirty-five in circumference, contributed undoubtedly to the concussion of the earth and air, which kept all the houses in Naples in a constant tremor for several hours, every door and window striking violently and every bell ringing. Vesuvius is composed of two mountains, the one called Somma, which has ceased to emit flames for many years; the other called Vesuvio.

Another tremendous report from Vesuvius, was succeeded by a fountain of liquid fire, which gradually increasing, arose to three times the height of the mountain itself, which is 3,700 feet above the level of the sea. Occasional clouds of the darkest smoke broke through this vast column of fire, and which, at length, collecting in one vast body, was carried by the wind to the farther side of the mountain, forming a gloomy back ground to the vivid glow upon Vesuvius. This liquid lava, after shooting up to all appearance ten thousand feet, was directed towards Ottiana, where it partly fell, red hot and liquid: the top of Vesuvius, the valley between that and Somma, and the summit of the latter, immediately assumed the appearance of a vast sheet of fire, extending two miles and a half in breadth.

To complete this terrific, yet sublime scene, the brush wood on the Somma took fire, the flame of which, being of a different hue from the deep red of the matter thrown from the volcano, and from the silvery blue of the electrical fire, still added to the contrast of this truly impressive scene.

The sky over Naples had been, till this period of the eruption, beautifully serene, the moon bright, and the stars shining with their usual lustre, but now the moon withdrew her pale light by degrees, till, her glory quite eclipsed, she totally disappeared, and the most awful darkness succeeded, save where Vesuvius threw a burning glow.

In Naples, fear and horror were visible on every countenance: a procession of monks, followed by an innumerable concourse of people, whose prayers and lamentations greatly heightened the solemnity of the scene, paraded the streets in every direction. When the black cloud already described, was borne by the wind towards Naples, their feelings rose almost to despair. This enormous black cloud was loaded with electric matter, which, in the form of lightning, darted in every direction; fortunately it returned to Vesuvius, without injuring the city, but the two small towns of Ottiana and Torre del Greco suffered dreadfully from the inflammatory contents; the latter was indeed nearly overwhelmed by the boiling lava, and the inhabitants escaped but with life. An immense promontory, which had been formed by the lava, and had passed over this town, was 1204 English feet in breadth; its height above the sea was twelve feet, and it extended into the sea 626 feet. The sea, for some days, was boiling like a cauldron round the foot of this newly-formed promontory, and even at a hundred yards from it, the water was scalding hot. A fisherman who went near it, observed that the pitch at the bottom of his boat was melting fast, and floating on the surface of the sea, and that his little vessel began to leak, he therefore hastily quitted the spot, and returned to Naples, deeply impressed with the awful calamity which had thus changed the whole face of the country.

But I promised you, in the beginning of this epistle, a description of Herculaneum and Pompeii, which I will now fulfil. In the year 1729, a part of the ruins was discovered by accident. A person having gone down a well near Portici, he discovered a passage which he crept into, and mentioning the circumstance to others, several persons went down with lights, and penetrating a great way, they discovered the foundation of streets and houses. This discovery being made known to the King of Naples, they began to make excavations through beds of lava, and at length discovered a theatre in the form of a horse shoe. That part where the spectators sat is still visible, and consists of eighteen rows of broad stone seats, one above another, in a circular form. Several little narrow flights of steps are still seen in various parts for the convenience of the spectators to ascend to the different ranges of seats. A large gallery leading round the outside of the theatre, may still be traced. The pavement must have been very beautiful from the specimens of coloured marble which still remain. In consequence of this discovery, they prosecuted their researches with considerable ardour, and their labour was repaid by a vast collection of busts, statues, cameos, and household utensils. An inkstand with ink in it, stylets or pens, eggs quite whole but empty, nuts and almonds, beans and peas burnt quite black, and many different fruits: medicines in pills, with their marks, a phial of oil, gold lace, in excellent preservation, and extremely curious, being spun out without any silk; soap, bran, &c. &c. and a loaf burnt to a coal, but still retaining the baker's mark, is now preserved with great care in a glass case. It is remarkable, that many of the weights and scales which were found, resemble those in use at the present day in Naples.

A skeleton was found in a door way, in a running attitude, with one arm extended, which appeared to have had a bag of money in it, for there is the impression of the bag in the lava, and some pieces of money were found in the spot beneath it. Herculaneum, most probably, was destroyed by the burning lava; for had the city been swallowed up by an earthquake, more skeletons would have been found, and every thing would have been displaced, which was not the case.

In Pompeii, a small closet was found entire; the painting on the walls and ceiling perfectly unhurt; on one side of it, was a marble table, fastened into the wall itself, which might be called a side-board, and on which was placed one of the most beautiful tripods ever seen, about three feet high, and in the highest perfection, a crescent of silver, about five inches in diameter, a silver amulet or charm, representing Hippocrates, and a golden fibulæ or broach, about an inch in diameter.

The most curious, however, of all the discoveries made in either city is this, a small leg and thigh of some animal, covered with silver, which is five inches long. On the external part of it is described a sun-dial, formed on a quadrant, and as the thigh forms the quarter of a circle, the workman has taken the centre of this quadrant from the extremity of the ham or gammon, and hence has drawn hour lines, which with the lines that mark the months, forms the usual compartments, some larger and others smaller, which are divided six by six, as well in height as in length. Below the inferior compartments, which are the less, are read the names of the months, placed in two lines, in a retrograde order, so that the month of January is the last in the first line, which bears the other five following months. In the second line are described the six other months in their natural order; so that the month of December is under January, and so the months shorter and longer, have one common compartment for each couple. Almost on the edge of the right side, there is the tail of the animal, somewhat bent, and this performs the office of gnomen. On the extremity of the leg, or centre of the quadrant, there is a ring to hold the dial in an equipoise, and it is supposed that in this place the plummet was fastened, such as in the like dials is to fall on the present month, to determine the shadow of the gnomen on the horary lines.

These are, I believe, the most striking articles which have been discovered, and if I were to attempt to give you even a correct list of the busts, statues, cameos, intaglios, found in these two subterraneous cities, I should write a volume. I trust you will be amused with this slight sketch, which has not, I hope, excited your regrets at not having seen these ruins. Believe me, you would have been disappointed, for the glory of Herculaneum and Pompeii has long since mouldered in oblivion, and the little that remains of these unfortunate cities, consists of excavated passages and defaced walls. Every thing valuable has been taken from them, and discovery is at length exhausted. Fare thee well.

FATHER BENEDICT.

The volcanoes of Etna, the Lipari Isles of Iceland, the Adriatic and African islands, and of America, have been described in several works. The following two articles have the novelty of presenting the eccentricity, if we may so speak, of the singular phenomena we are now investigating.

Mud Volcanoes of Trinidad.

10. In 1816, Dr. Ferguson visited this island, and found that in the eruptions of these semi-volcanoes, the matter thrown out is always *cold*. They are situated at the southern extremity of Trinidad, on a narrow tongue of land, which points directly into one of the mouths of the Oroonoko on the main, and not far from the celebrated pitch-lake.

Dr. Ferguson observed that the matter ordinarily thrown out, consisted of argillaceous earth mixed with salt water, about as salt as the water in the neighbouring gulf of Paria: but, though cold at all times, that pyritic fragments are occasionally ejected along with the argillaceous earth. He also observed that several mounts in the vicinity, possessed the same character in all respects, as the semi-volcanoes then in activity; having all the marks, except the actual eruption, of having been raised through a similar process to their present height of about one hundred feet; and that the trees around them were of the same kind that are found near lagoons and salt marshes.

M. Humboldt says, that at Monai in South America, there is a stratum of clayey earth, which inflames spontaneously, when slightly moistened and exposed for a long time to the rays of the tropical sun. The detonation of this muddy substance is very violent. It is of a black colour, soils the fingers, and emits a strong smell of sulphur.

Mud Volcanoes of Crobogan in Java.

11. In September 1817, the mud volcanoes of Crobogan, in Java, fifty miles from Solo, were witnessed by a party of which S. Goad, Esq. was one.

On approaching the village of Kuhoo, the travellers saw, between two trees in a plain, an appearance like the surf breaking over rocks, with a strong spray falling to leeward. The spot was completely surrounded by huts for the manufacture of salt. Alighting, they went to the Bludugs, as the Javanese call them; and found them to be on an elevated plain of mud, about two miles in circumference, in the centre of which immense bodies of salt mud were thrown up to the height of from ten to fifteen feet, in the forms of large globes, which, bursting, emitted volumes of dense white smoke. These large globes or bubbles, of which there were two, continued throwing up and bursting seven or eight times in a minute by the watch. At times they threw up two or three tons of mud.

The party got to leeward of the smoke, and found it to smell like the washing of a gun barrel. As the globes burst, they threw the mud out from the centre, with a pretty loud noise, occasioned by the falling of the mud upon that which surrounded it, and of which the plain is composed. It was difficult and dangerous to approach the large globes or bubbles, as the ground was all a quagmire, except where the surface of the mud had become hardened by the sun; upon this they approached cautiously to within fifty yards of the largest bubble or mud pudding, as it might very properly be called, for it was of the consistency of a custard pudding, and of very considerable diameter. They also got close to a small globe or bubble (the plain was full of them of different sizes) and observed it closely for some time. It appeared to heave and swell, and, when the internal air had raised it to some height, it burst, and the mud fell down in concentric circles, in which shape it remained quiet until a sufficient quantity of air was again formed internally to raise and burst another bubble. This continued at intervals from about one-half to two minutes.

From various other parts of the quagmire, round the large globes or bubbles, there were occasionally small quantities of mud shot up like rockets, to the height of twenty or thirty feet, and accompanied by smoke. This was in parts where the mud was of too stiff a consistency to rise in globes or bubbles. The mud at all the places they came near was cold on the surface, but they were told it was warm beneath. The water which drains from the mud is collected by the Javanese, and, by being exposed in the hollows of split bamboos to the rays of the sun, deposits crystals of salts.

In the two articles following, and with which we will close our notices of volcanoes, the reader is presented with every thing worthy of observation on this interesting topic.

Pseudo Volcano.

12. This volcano is situated near Bilston, on the road side, between Birmingham and Wolverhampton. Dr. Plott relates that it was on fire in 1686, but it was not known how long it had been in a state of combustion. Its space was then eleven acres, but its ravages have since extended throughout a square mile. Its origin and continuance are no doubt owing to strata of pyrites, (which are a compound of sulphur and iron,) existing among the coals.

In the year 1815, it began to penetrate through the floors of some houses: it produced great alarm, by appearing in the night; and four of the houses were taken down. It exhibits a red heat in this situation, and the smoke has forced its way through a bed of cinders forty feet in height. On the south it is arrested by beds of sand, which cover the coal formation: and on the north-east it is impeded by cultivation. At first view, a stranger might suppose himself in a volcanic region. The exterior view of the strata, exposed by the falling in of the ground, presents a surface blackened by the action of fire, and presenting most of the porphyritic and trappear colours in high perfection. The cinder dust under foot, the sulphureous vapour and smoke which arise from the various parts of the surface, and the feeling of insecurity which attend the footsteps, all combine to give a high degree of interest to the scene. The minerals found in this region are, *sulphur*, in small brilliant massy cyrstals, also *mineral tar*; *coal*, in some places only four feet from the surface; *sulphate of alumine*; *muriate of ammonia*, combined with a small proportion of *sulphate of ammonia*; *sulphate of zinc*; *sulphate of lime*; *porcelain jasper*; *newest floetz trap*, *basalt*, or *rowley-rag*.

Artificial Volcano.

13. Mix together half a hundred weight of sulphur with the same quantity of iron filings, forming

the whole into a paste, with so much water as is necessary. Now dig a hole three feet deep in the earth, and bury the mass; laying the earth over it very compact, and raising a mound like a small ant-hill, on the top, to mark its situation. If this experiment be performed in the warm season of the year, so much heat will be engendered in the course of twelve or fourteen hours, as to swell and burst the earth, causing an artificial volcano, by throwing up whatever impedes its progress, and scattering in all directions ashes of a yellow and black colour.

This experiment should be performed in the centre of a field, and the spot where the mass is deposited should not be approached after the tenth hour of burying, as the consequence might be dangerous.

The cause of this phenomenon is the affinity which the iron filings have for the oxygen of the water. During this combination, the sulphur attracts the hydrogen, and much heat being evolved during this play of affinities, the combustible matters swell the earth, and burst into flame. The matter thrown out will be found to be vitrified earth, sulphur, and oxide of iron.

Geologists are universally agreed, that a similar composition, called iron pyrites, imbedded in the bowels of the earth, is the cause of similar natural phenomena, when water comes in contact with it; though, of course on a much larger scale. It is certain that in all volcanic regions sulphur and iron abound.

SECTION III.

VOLCANIC REACTIONS.

The Earthquake of the Caraccas.

On the subject of earthquakes, the field of observation is both varied and extensive; but the scientific description of one is worth the detail of fifty, where the marvellous hath supplied knowledge, and fear has shrunk from the investigation of the causes that produce these phenomena.

15. There are few events in the physical world

which are calculated to excite so deep and permanent an interest as the earthquake which destroyed the town of Caraccas in 1812, and by which more than 20,000 persons perished, almost at the same instant, in the province of Venezuela, in South America.

The 26th of March was a remarkably hot day. The air was calm, and the sky unclouded. It was Holy Thursday, and a great part of the population was assembled in the churches. Nothing seemed to presage the calamities of the day. At seven minutes after four in the afternoon the first shock was felt; it was sufficiently powerful to make the bells of the churches toll; it lasted five or six seconds, during which time the ground was in a continual undulating movement, and seemed to heave up like a boiling liquid. The danger was thought to be past, when a tremendous subterraneous noise was heard, resembling the rolling of thunder, but louder, and of longer continuance than that heard within the tropics in time of storms. This noise preceded a perpendicular motion of three or four seconds, followed by an undulatory movement somewhat longer. The shocks were in opposite directions, from north to south, and from east to west. Nothing could resist the movement from beneath upward, and undulations crossing each other. The town of Caraccas was entirely overthrown. Between nine and ten thousand of the inhabitants were buried under the ruins of the houses and churches. The procession had not yet set out; but the crowd was so great in the churches, that nearly three or four thousand persons were crushed by the fall of their vaulted roofs. The explosion was stronger towards the north, in that part of the town situated nearest the mountain of Avila, and the Silla. The churches of la Trinidad and Alta Gracia, which were more than 150 feet high, and the naves of which were supported by pillars of twelve or fifteen feet diameter, left a mass of ruins scarcely exceeding five or six feet in elevation. The sinking of the ruins has been so considerable, that there now scarcely remain any vestiges of pillars or columns. The barracks, called *El Quartel de San Carlos,* situate farther north of the church of the Trinity, on the road from the custom-house de la Pastora, almost entirely disappeared. A regiment of troops of the line, that was assembled under arms, ready to join the procession, was, with the exception of a few men, buried under the ruins of this great edifice. Nine-tenths of the fine town of Caraccas were entirely destroyed. The walls of the houses that were not thrown down, as those of the street San Juan, near the Capuchin Hospital, were cracked in such a manner, that it was impossible to run the risk of inhabiting them.

Estimating at nine or ten thousand the number of the dead in the city of Caraccas, we do not include those unhappy persons, who, dangerously wounded, perished several months after, for want of food and proper attention. The night of Holy Thursday presented the most distressing scene of desolation and sorrow. That thick cloud of dust, which, rising above the ruins, darkened the sky like a fog, had settled on the ground. No shock was felt, and never was a night more calm or more serene. The moon, nearly full, illumined the rounded domes of the Silla, and the aspect of the sky formed a perfect contrast to that of the earth, covered with the dead, and heaped with ruins. Mothers were seen bearing in their arms their children, whom they hoped to recall to life. Desolate families wandered through the city, seeking a brother, a husband, a friend, of whose fate they were ignorant, and whom they believed to be lost in the crowd. The people pressed along the streets, which could no more be recognised but by long lines of ruins.

All the calamities experienced in the great catastrophes of

Lisbon, Messina, Lima, and Riobamba, were renewed on the fatal day of the 26th of March, 1812. The wounded, buried under the ruins, implored by their cries the help of the passers by, and nearly 2000 were dug out. Implements for digging, and clearing away the ruins were entirely wanting; and the people were obliged to use their bare hands to disinter the living. The wounded, as well as the sick who had escaped from the hospitals, were laid on the banks of the small river Guayra. They found no shelter but the foliage of trees. Beds, linen to dress the wounds, instruments of surgery, medicines, and objects of the most urgent necessity, were buried under the ruins. Every thing, even food, was wanting during the first days. Water became alike scarce in the interior of the city. The commotion had rent the pipes of the fountains; the falling in of the earth had choked up the springs that supplied them; and it became necessary, in order to have water, to go down to the river Guayra, which was considerably swelled; and then vessels to convey the water were wanting.

There remained a duty to be fulfilled towards the dead, enjoined at once by piety and the dread of infection. It being impossible to inter so many thousand corpses, half-buried under the ruins, commissaries were appointed to burn the bodies: and for this purpose, funeral piles were erected between the heaps of ruins. This ceremony lasted several days. Amid so many public calamities, the people devoted themselves to those religious duties which they thought were the most fitted to appease the wrath of heaven. Some, assembling in procession, sung funeral hymns; others, in a state of distraction, confessed themselves aloud in the streets. In this town was now repeated what had been remarked in the province of Quito, after the tremendous earthquake of 1797; a number of marriages were contracted between persons who had neglected for many years to sanction their union by the sacerdotal benediction. Children found parents by whom they had never till then been acknowledged; restitutions were promised by persons, who had never been accused of fraud; and families, who had long been enemies, were drawn together by the tie of common calamity. If this feeling seemed to calm the passions of some, and open the heart to pity, it had a contrary effect on others, rendering them more rigid and inhuman.

Shocks as violent as those which, in the space of one minute *, overthrew the city of Caraccas, could

* The duration of the earthquake, that is to say, the whole of the movements of undulation and rising which occasioned

not be confined to a small portion of the continent. Their fatal effects extended as far as the provinces of Venezuela, Varinas, and Maracaybo, along the coast; and still more to the inland mountains. La Guayra, Mayquetia, Antimano, Baruta, La Vega, San Felipe, and Merida, were almost entirely destroyed. The number of the dead exceeded four or five thousand at La Guayra and the town of San Felipe, near the copper-mines of Aroa. It appears, that it was on a line running east north-east, and west south-west, from La Guayra and Caraccas to the lofty mountains of Niquitao and Merida, that the violence of the earthquake was principally directed. It was felt in the kingdom of New Granada from the branches of the high Sierra de Santa Martha as far as Santa Fe de Bogota and Honda, on the banks of the Magdalena, 180 leagues from Caraccas. It was every where more violent in the Cordilleras of gneiss and mica-slate, or immediately at their foot, than in the plains: and this difference was particularly striking in the savannahs of Varinas and Casanara. In the valleys of Aragua, situate between Caraccas and the town of San Felipe, the commotions were very weak: and La Victoria, Maracay, and Valentia, scarcely suffered at all, notwithstanding their proximity to the capital. At Valecillo, a few leagues from Valencia, the earth, opening, threw out such an immense quantity of water, that it formed a new torrent. The same phenomenon took place near Porto-Cabello. On the other hand, the lake of Maracaybo diminished sensibly. At Coro no commotion was felt, though the town is situated upon the coast, between other towns which suffered from the earthquake.

Fifteen or eighteen hours after the great catastrophe, the ground remained tranquil. The night, as we have already

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the horrible catastrophe of the 26th of March, 1812, was estimated by some at 50″, by others at 1′ 12″.

observed, was fine and calm; and the commotions did not recommence till after the 27th. They were then attended with a very loud and long-continued subterranean noise. The inhabitants of Caraccas wandered into the country; but the villages and farms having suffered as much as the town, they could find no shelter till they were beyond the mountains of Los Teques, in the valleys of Aragua, and in the Llanos or savannahs. No less than fifteen oscillations were often felt in one day. On the 5th of April there was almost as violent an earthquake, as that which overthrew the capital. During several hours, the ground was in a state of perpetual undulation. Large masses of earth fell in the mountains; and enormous rocks were detached from the Silla of Caraccas. It was even asserted and believed that the two domes of the Silla sunk fifty or sixty toises; but this assertion is founded on no measurement whatever.

While violent commotions were felt at the same time in the valley of the Mississippi, in the island of St. Vincent, and in the province of Venezuela, the inhabitants of Caraccas, of Calabozo, situated in the midst of the steppes, and on the borders of the Rio Apura, in a space of 4000 square leagues, were terrified on the 30th of April, 1812, by a subterraneous noise, which resembled frequent discharges of the largest cannon. This noise began at two in the morning. It was accompanied by no shock; and, what is very remarkable, it was as loud on the coast as at eighty leagues distance inland. It was every where believed to be transmitted through the air; and was so far from being thought a subterraneous noise, that at Caraccas, as well as at Calabozo, preparations were made to put the place into a state of defence against an enemy, who seemed to be advancing with heavy artillery. Mr. Palacio, crossing the Rio Apura near the junction of the Rio Nula, was told by the inhabitants that the "firing of cannon" had been heard as distinctly at the western extremity of the province of Varinas, as at the port of La Guayra to the north of the chain of the coast.

The day on which the inhabitants of Terra Firma were alarmed by a subterraneous noise, was that on which happened the eruption of the volcano in the island of St. Vincent. This mountain, near five hundred toises high, had not thrown out any lava since the year 1718. Scarcely was any smoke perceived to issue from its top, when, in the month of May, 1811, frequent shocks announced that the volcanic fire was either rekindled, or directed anew toward that part of the West Indies. The first eruption did not take place till the 27th of April, 1812, at noon. It was only an ejection of ashes, but attended with a tremendous noise. On the 30th, the lava passed the brink of the crater, and, after a course of four hours, reached the sea. The noise of the explosion resembled that of alternate discharges of very large cannon and of musketry; and, what is well worthy of remark, it seemed much louder at sea, at a great distance from the island, than in sight of land, and near the burning volcano.

The distance in a straight line from the volcano of St. Vincent to the Rio Apura, near the mouth of the Nula, is 210 nautical leagues. The explosions were consequently heard at a distance equal to that between Vesuvius and Paris. This phenomenon, connected with a great number of facts observed in the Cordilleras of the Andes, shows how much more extensive the subterranean sphere of activity of a volcano is, than we are disposed to admit from the small changes effected at the surface of the globe. The detonations heard during whole days together in the New World, 80, 100, or even 200 leagues distant from a crater, do not reach us by the propagation of sound through the air; they are transmitted to us by the ground. The little town of Honda, on the banks of the Magdalena, is not less than 145 leagues from Cotopaxi; and yet in the great explosions of this volcano, in 1744, a subterraneous noise was heard at Honda, and supposed to be discharges of heavy artillery. The monks of St. Francis spread the news, that the town of Carthagena was bombarded by the English; and the intelligence was believed. Now the volçano of Cotopaxi is a cone, more than 1800 toises above the basin of Honda, and rises from a table-land, the elevation of which is more than 1500 toises above the valley of the Magdalena. In the colossal mountains of Quito, of the provinces of Los Pastos, and of Popayan, crevices and valleys without number are interposed. It cannot be admitted, under these circumstances, that the noise could be transmitted through the air, or by the superior surface of the globe, and that it came from that point, where the cone and crater of Cotopaxi are placed. It appears probable, that the higher part of the kingdom of Quito and the neighbouring Cordilleras, far from being a group of distinct volcanoes, constitute a single swollen mass, an enormous volcanic wall, stretch from south to north, and the crest of which exhibits a surface of more than six hundred square leagues. Cotopaxi, Tunguragua, Antisana, and Pichincha, are placed on this same vault, on this raised ground. The fire issues sometimes from one, sometimes from another of these summits. The obstructed craters appear to be extinguished volcanoes; but we may presume, that, while Cotopaxi or Tunguragua have only one or two eruptions in the course of a century, the fire is not less continually active under the town of Quito, under Pichincha and Imbaburu.

Advancing toward the north, we find, between the volcano of Cotopaxi and the town of Honda, two other *systems of volcanic mountains*, those of Los Pastos and of Popayan. The connection of these systems was manifested in the Andes in an incontestible manner by a phenomenon, which I have already had occasion to notice. Since the month of November, 1796, a thick column of smoke had issued from the volcano of Pasto, west of the town of that name, and near the valley of Rio Guaytara. The mouths of the volcano are lateral, and placed on its western declivity, yet during three successive months the column rose so much higher than the ridge of the mountain, that it was constantly visible to the inhabitants of the town of Pasto. They related to us their astonishment, when, on the 4th of February, 1797, they observed the smoke disappear in an instant, without feeling any shock whatever. At that very moment, sixty-five leagues to the south, between Chimborazo, Tunguragua, and the Altar (Capac Urcu,) the town of Riobamba was overthrown by the most dreadful earthquake of which tradition has transmitted the history. Is it possible to doubt from this coincidence of phenomena, that the vapours issuing from the small apertures or *ventanillas* of the volcano of Pasto, had an influence on the pressure of those elastic fluids, which shook the ground of the kingdom of Quito, and destroyed in a few minutes thirty or forty thousand inhabitants?

In order to explain these great effects of *volcanic reactions*, and to prove, that the group or system of the volcanoes of the West India Islands may sometimes shake the continent, it was necessary to cite the Cordillera of the Andes. Geological reasoning can be supported only on the analogy of facts that are recent, and consequently well authenticated: and in what other region of the globe could we find greater, and at the same time more varied volcanic phenomena, than in that double chain of mountains heaved up by fire? in that land, where nature has covered every summit and every valley with her wonders? If we consider a burning crater only as an insulated phenomenon, if we satisfy ourselves with examining the mass of stony substances which it has thrown up, the volcanic action at the surface of the globe will appear neither very powerful nor very extensive. But the image of this action swells in the mind, when we study the relations that link together volcanoes of the same group; for instance, those of Naples and Sicily, of the Canary Islands, of the Azores, of the Caribbee Islands, of Mexico, of Guatimala, and of the table-land of Quito; when we examine either the reactions of these different systems of volcanoes on one another, or the distance to which, by subterranean communications, they at the same moment shake the earth *.

Such is M. Humboldt's history of the earthquake at the Caraccas: the following account of one nearer home, resembles the trembling of the aspin leaf in comparison of that in the New World.

Earthquake in the North of Scotland, in 1816.

15. On Tuesday, the 13th of August, at 25 minutes past 10, p.m. (the evening being uncommonly calm; the thermometer at 60 degrees, and the barometer at 29.8,) a violent shock of an earthquake was felt, extending from north-west to south-east, which lasted for about ten seconds. It was accompanied by a rumbling sound, which appeared

* The following is the series of phenomena which M. Humboldt supposes to have had the same origin:

27th September, 1796. Eruption in the West India Islands. Volcano of Guadaloupe.—November, 1796. The volcano of Pasto begins to emit smoke.—14th of December, 1796. Destruction of Cumana.—4th of February, 1797. Destruction of Riobamba.—30th of January, 1811. Appearance of Sabrina Island, in the Azores. It increases particularly on the 15th of June, 1811.—May, 1811. Beginning of the earthquakes in the Island St. Vincent, which lasted till May, 1812.—16th of December, 1811. Beginning of the commotions in the Valley of the Mississippi and the Ohio, which lasted till 1813. —December, 1811. Earthquake at Caraccas.—26th of March, 1812. Destruction of Caraccas. Earthquakes which continued till 1813.—30th April, 1812. Eruption of the volcano at St. Vincent's; and the same day, subterranean noises at Caraccas, and on the banks of the Apura.

at first to come from underneath, but immediately afterwards resembled the sound of a coach and four, driving full speed along a street; and in a second after, it appeared to come from the roofs of the houses, and as if a number of persons were forcibly bursting open the doors. Dogs howled violently, and appeared sensible of something supernatural. In one house, two canary birds in a cage, were so much frightened, as to drop down dead.

The houses in many towns, shook with great violence; some were rent asunder; chimneys were thrown down, windows and glasses were broken, and the public and private bells added an incessant clangour to the general confusion.

To the westward, the shock was very violent. At Inverness, the beautiful spire of the gaol and court-house was thrown about eight inches off the perpendicular, for about twelve feet at the top, and only supported from falling by a long iron rod, to which the weathercock is attached.

Many chimneys were thrown down, no fewer than seven in one court, and several houses rent from top to bottom.

In the district of country west from Inverness, called the Aird, the shock was still more violent; the houses of Phopachy, Bogsey, &c. were completely rent from top to bottom. Fortunately, no lives were lost, but the families were obliged to leave them immediately. The east end of the old priory of Beemly was likewise thrown down.

At Fort George, the ramparts shook so violently, that the sentinels on duty at the main gate, conceived an attempt was made to force it open, and, under this idea, challenged the supposed intruders. The range of front buildings occupied as the governor's, lieutenant-governor's, and the other staff-officers' houses, appeared to the soldiers on guard to be bowed violently backward and forward, or, as one of them expressed it, to be shaken like a strong ash-tree in a violent storm. The sea appeared much agitated, and, at the ferry of Kessoc, the boatmen, who were at the time crossing it, experienced three violent waves, such as must have sunk the boat had there been any wind; indeed they conceived they had run upon some sand-bank.

About one, a. m. a second, but slight, shock was experienced; but, from the hour, was only noticed by a few.

The mercury in the barometer was much agitated immediately after the earthquake, and a small fire-ball was observed in the air, in a direction from north to south, immediately succeeding it.

SECTION IV.

VOLCANIC ISLANDS, &c.

Volcanic Island lately thrown up among the Aleutian Islands.

16. A new volcanic island has been raised among the Aleutian Islands, not far from Unalaschka. This phenomenon appeared in the midst of a storm, attended with flames and smoke. After the sea was calmed, a boat was sent from Unalaschka, with twenty Russian hunters, who landed on this island, June 1st, 1814.

They found it full of crevices and precipices. The surface was cooled to the depth of a few yards, but below that depth it was still hot. No water was found on any part of it. The vapours rising from it were not injurious, and the sea-lions had began to take up their residence on it. Another visit was paid to it in 1815; its height was then diminished. It is about two miles in length; they have given it the name of Boguslaw.

Geological Account of the Island of Jan Mayor.

17. This remote and desolate spot, situated in lat. 70° 49′ N. and long. 7° 25′ W. was visited by Capt. Scoresby in Aug. 1817. On approaching, the first object which strikes the attention is the mountain of Beerenberg, which rears its icy summit to the height of 6840 feet above the level of the

sea. All the high lands were covered with snow; and the low lands in deep cavities still retained part of their winter covering down to the very margin of the sea. Captain S. observed three remarkable ice bergs, having a perpendicular height of 1284 feet.

The beach was covered with a sand having the appearance of coarse gun-powder: being a mixture of iron, sand, olivine, and augite. As he advanced towards the rocks, he found masses of lava, blocks of burned clay, and masses of baked clay. He ascended to the summit of a volcanic mountain 1500 feet above the sea, where he beheld a crater forming a basin of 500 or 600 feet deep. From this eminence, the country in all directions appeared bleak and rugged in the extreme;—all indicated the action of volcanic fire; the plants were few in number; the animals were blue foxes. He also saw the feet-marks of bears, and he thinks rein-deer; but few birds were seen.

Geological Structure of St. Vincent's, one of the West India Islands.

18. St. Vincent's, like all other volcanic islands, is composed of a mixture of lava and cinders, in all proportions. South of Kingston, there appears to be more solid and porous lava, and less cinders than at the north. The Bay of Kingston has the appearance of being the remains of an ancient crater, the beds of lava inclining irregularly from the centre, at a considerable dip, as if they had been ejected from it. On every side, the rocks are aggregates of various kinds of roasted stones, cemented with cinders, and small atoms of scoria; and though many of the rolled rocks neither bear strong marks of fusion, nor resemble much recent lavas, yet they all have a family feature, and must be considered of volcanic origin. A substance like hornblend, with feldspar imbedded in it, forms the principal part of these rocks, which vary in colour, from nearly black to grey, the feldspar being generally

crystallized, and frequently diaphanous, passing through the porous or scorious rocks without indications of having undergone much change.

There are two principal modes by which the production of cinders or ashes may be accounted for; they may be thrown from the crater of a volcano during an eruption of lava, and in that case they consist of small pieces of scoria, pumice, &c. and are placed in strata of various thicknesses and colours, as if deposited by water; or they may be ejected from volcanoes nearly exhausted mixed with water and rocks, forming large beds or currents of an aggregate, which is in time cemented, and wears the appearance of a breccia. A third mode is, perhaps, the eruption of lava into the sea, at the commencement of submarine volcanoes, when by means of the sudden cooling, the melted lava might crumble into small angular sand, and form beds of cinders. From Kingston to the north end of the island, the same alternation of cinders and solid lava obtains, forming steep precipices and narrow vallies, the wearing and excavation of which, by the mountain torrents, is facilitated by the prevalence of the cinders which increase as you approach the *Soufriere*, a name given in the West Indies, to spots which indicate the remains of a subsiding volcano, and whence hot sulphureous vapours are ejected through *fumerols*, depositing sulphur, and converting the surrounding aluminous rocks into alum-stone, as at Solfaterra near Naples.

The fumerols of this Soufriere are at present extinguished, perhaps by the last irruption of cinders in 1812, when the crater threw forth a mixture of water, rocks, and cinders in a state approaching to ignition, resembling a current of lava; burning the woods, and filling all the channels of the little rivers that descend the mountain, and rising sometimes to the height of three or four hundred feet. Very fine cinders fell on the decks of vessels three or four hundred miles to windward, supposed to have been carried by a counter current of air, in the upper regions of the atmosphere.

This irruption consisted of a great quantity of angular sand, the broken masses of roasted and vitrified rocks being mixed with loose angular pieces of all sizes, brittle, and crumbling under the hammer

These imbedded rocks are, 1st. A rock resembling a small and middling sized grained granite, roasted, with diaphanous feldspar. 2nd, A gray rock, in plates, like gneiss, but much altered by the fire. 3d, A feldspar and hornblend rock, the feldspar crystallized and diaphanous, with the appearance of having been roasted. 4th, A hornblend rock, crystalline, having a roasted appearance. 5th, A dark coloured rock, with a conchoidal, even, vitreous fracture, containing crystals of feldspar, some pieces so vitreous as to resemble pitchstone, and porphyry running through all the gradations from a grey rock, scarcely vitrified, to a total vitrification, and thence to a porous scoria, not unlike pumice, with transparent crystals of feldspar, taking a deeper tinge of black in proportion to the degree of vitrification. 6th. A bluish rock with feldspar, and some black crystals, having all the appearance of compact lava.

If we suppose that volcanic action tends to form large cavities under the places whence the lava, &c. issues, and that one, or more, of these cavities, where the combustible materials are exhausted, becomes filled with water, while other cavities, where these materials still remain, are filled with lava, &c. it would appear only necessary to unite the contents of two such caverns to produce all the effects of an irruption of cinders.

Island of Ischia, near Naples.

19. To the most superficial observer, the surface of this island exhibits the effects of fire, and volcanic productions; besides many craters, long extinct; and strata of lava, in different stages of vegetation. The lava of the most recent eruption, in 1301, even now bears only a few scattered blades of grass, and some weeds. Hence we may judge how slowly nature operates on this hard substance, when not assisted by the soil washed down from the declivities of mountains, or wafted by the wind. If we examine the many craters with which this spot abounds, particularly the large crater between Ischia and Testaccio, close to the side of the road; if we next turn our view to the adjoining mountains, at present covered with a deep soil, and clothed

with wood, we may calculate the high antiquity, not only of such eruptions, but of the globe itself.

Indeed, amidst the various evidences which have been adduced by those authors who have chosen to controvert the general opinion on the supposed age of the world, none seem to carry more force than those deduced from the investigation of volcanic matter. Nor are these evidences founded on mere conjecture; for the dates of many eruptions are known; and, by tracing the strata of lava, and the marine bodies interspersed, and comparing the relative progress of vegetation over each, we may draw a very probable conclusion in regard to the age of the more remote; and, perhaps, may be induced to give the world a higher degree of antiquity than is commonly admitted.

For nearly five centuries this island has ceased to exhibit any volcanic eruption; but the numerous hot springs, which continue to emit their vapour, prove that subterraneous fire still exists. Besides these warm springs, however, there are others of an opposite nature; and from the same mountain which produces the sulphureous and medical waters, a cold spring issues, of the purest quality, and is conveyed by aqueducts to the town of Ischia.

The lofty mountain now bearing the name of St. Nicolo, is the Epopeus of the classic writers.

Like Ætna, it may be divided into three regions; the lower cultivated, the middle clothed with rich groves of oaks and chesnuts, and the upper bleak and barren, producing only a few low shrubs and dwarf trees.

It is not, however, without inhabitants; for, on this aërial summit, some hermits have fixed their abode; and no anchorite certainly ever selected a more appropriate spot. Exalted above the dwellings, as they profess to be above the passions of men, they may look down with an eye of indifference on a prodigious expanse of territory, thickly dotted with towns and villages; and, contrast their homely fare and tranquil situation with the cares and troubles which attend the wealth and luxury of the world beneath.

Captain Tillard's Account of the Volcanic Island of Sabrina.

Approaching, says he, the island of St. Michael's, on Sunday, June 12, 1811, in his Majesty's sloop Sabrina, under my command, we occasionally observed, rising in the horizon, two or three columns of smoke, such as would have been occasioned by an action between two ships, to which cause we universally attributed its origin. This opinion was, however, in a very short time changed, from the smoke increasing and ascending in much larger bodies than could possibly have been produced by such an event; and having heard an account, prior to our sailing from Lisbon, that in the preceding January or February a volcano had burst out within the sea near St. Michael's, we immediately concluded that the smoke we saw proceeded from that cause, and on our anchoring next morning in the road of Ponta del Gada, we found this conjecture correct as to the cause, but not to the time; the eruption of January having totally subsided, and the present one having only burst forth two days prior to our approach, and about three miles distant from the one before alluded to.

Desirous of examining as minutely as possible a contention so extraordinary between two such powerful elements, I set off from the city of Ponta del Gada on the morning of the 14th, in company with Mr. Read, the Consul General of the Azores, and two other gentlemen. After riding about twenty miles across the N.W. end of the island of St. Michael's, we came to the edge of a cliff, from whence the volcano burst suddenly upon our view in the most terrific and awful grandeur. It was only a short mile from the base of the cliff, which was nearly perpendicular, and formed the margin of the sea; the cliff being, as nearly as I could judge, from three to four hundred feet high. To give you an adequate idea of the scene by description is far beyond my powers; but for your satisfaction I shall attempt it.

Imagine an immense body of smoke rising from the sea, the surface of which was marked by the silvery rippling of the waves, occasioned by the light and steady breezes incidental to those climates in summer. In a quiescent state, it had the appearance of a circular cloud revolving on the water like an horizontal wheel, in various and irregular involutions, expanding itself gradually on the lee side, when suddenly a column of the blackest cinders, ashes, and stones would shoot up in form of a spire at an angle of from ten to twenty degrees from a perpendicular line, the angle of inclination being universally to windward: this was rapidly succeeded by a second, third, and fourth, each acquiring greater velocity, and overtopping the other till they had attained an altitude as much above the level of our eye, as the sea was below it.

As the impetus with which the columns were severally propelled, diminished, and their ascending motion had nearly ceased, they broke into various branches resembling a groupe of pines, these again forming themselves into festoons of white feathery smoke in the most fanciful manner imaginable, intermixed with the finest particles of falling ashes, which at one time assumed the appearance of innumerable plumes of black and white ostrich feathers surmounting each other; at another, that of the light wavy branches of a weeping willow.

During these bursts, the most vivid flashes of lightning continually issued from the densest part of the volcano; and the cloud of smoke now ascending to an altitude much above the highest point to which the ashes were projected, rolled off in large masses of fleecy clouds, gradually expanding themselves before the wind in a direction nearly horizontal, and drawing up to them a quantity of water-spouts, which formed a most beautiful and striking addition to the general appearance of the scene.

That part of the sea where the volcano was situated, was upwards of thirty fathoms deep, and at the time of our viewing it the volcano was only four days old. Soon after our arrival on the cliff, a peasant observed he could discern a peak above the water: we looked, but could not see it; however, in less than half an hour it was plainly visible, and before we quitted the place, which was about three hours from the time of our arrival, a complete crater was formed above the water, not less than twenty feet high on the side where the greatest quantity of ashes fell; the diameter of the crater being apparently about four or five hundred feet.

The great eruptions were generally attended with a noise like the continued firing of cannon and musquetry intermixed, as also with slight shocks of earthquakes, several of which having been felt by my companions, but none by myself, I had become half sceptical, and thought their opinion rose merely from the force of imagination; but while we were sitting within five or six yards of the edge of the cliff, partaking of a slight repast which had been brought with us, and were all busily engaged, one of the most magnificent bursts took place which we had yet witnessed, accompanied by a very severe shock of an earthquake. The instantaneous and involuntary movement of each was to spring upon his feet, and I said, "This admits of no doubt." The words had scarce passed my lips, before we observed a large portion of the face of the cliff, about fifty yards on our left, falling, which it did with a violent crash. So soon as our first consternation had a little subsided, we removed about ten or a dozen yards further from the edge of the cliff, and finished our dinner.

On the succeeding day, June 15th, having the consul and some other friends on board, I weighed, and proceeded with the ship towards the volcano, with the intention of witnessing a night view; but in this expectation we were greatly disappointed, from the wind freshening and the weather becoming thick and hazy, and also from the volcano itself being clearly more quiescent than it was the preceding day. It seldom emitted any lightning, but occasionally as much flame as may be seen to issue from the top of a glass-house or foundery chimney.

On passing directly under the great cloud of smoke, about three or four miles distant from the volcano, the decks of the ship were covered with fine black ashes, which fell intermixed with small rain. We returned the next morning, and late on the evening of the same day I took my leave of St. Michael's to complete my cruize.

Returning again towards St. Michael's on the 4th of July, I was obliged, by the state of the wind, to pass with the ship very close to the island, which was now completely formed by the volcano, being nearly the height of Matlock High Tor, about eighty yards above the sea. At this time it was perfectly tranquil; which circumstance determined me to land, and explore it more narrowly.

I left the ship in one of the boats, accompanied by some of the officers. As we approached, we perceived that it was still smoking in many parts, and upon our reaching the island, found the surf on the beach very high. Rowing round the lee side, with some little difficulty, by the aid of an oar, as a pole, I jumped on shore, and was followed by the other officers. We found a narrow beach of black ashes, from which the side of the island rose in general too steep to admit of our ascending; and where we could have climbed up, the mass of water was much too hot to allow our proceeding more than a few yards in the ascent.

The declivity below the surface of the sea was equally steep, having seven fathoms water scarce the boat's length from the shore, and at the distance of twenty or thirty yards we sounded twenty-five fathoms.

From walking round it in about twelve minutes, I should judge that it was something less than a mile in circumference; but the most extraordinary part was the crater, the mouth of which, on the side facing St. Michael's, was nearly level with the sea. It was filled with water, at that time boiling, and was emptying itself into the sea by a small stream about six yards over, and by which I should suppose it was continually filled again at high water. This stream, close to the edge of the sea, was so hot, as only to admit the finger to be dipped suddenly in, and taken out again immediately.

It appeared evident, by the formation of this part of the island, that the sea had, during the eruptions, broke into the crater in two places, as the east side of the small stream was bounded by a precipice, a cliff between twenty and thirty feet high forming a peninsula of about the same dimensions in width, and from fifty to sixty feet long, connected with the other part of the island by a narrow ridge of cinders and lava, as an isthmus of from forty to fifty feet in length, from which the crater rose in the form of an amphitheatre.

This cliff, at two or three miles distance from the island, had the appearance of a work of art resembling a small fort or block-house. The top of this we were determined, if possible, to attain; but the difficulty we had to encounter in doing so was considerable; the only way to attempt it was up the side of the isthmus, which was so steep that the only mode by which we could effect it, was by fixing the end of an oar at the base, with the assistance of which we forced ourselves up in nearly a backward direction.

Having reached the summit of the isthmus, we found another difficulty, for it was impossible to walk upon it, as the descent on the other side was immediate, and as steep as the one we had ascended; but by throwing our legs across it, as would be done on the ridge of a house, and moving ourselves forward by our hands, we at length reached that part of it where it gradually widened itself and formed the summit of the cliff, which we found to have a perfectly flat surface, of the dimensions before stated.

Judging this to be the most conspicuous situation, we here planted the Union, and left a bottle sealed up containing a small account of the origin of the island, and of our having landed upon it, and naming it Sabrina Island.

Within the crater I found the complete skeleton of a guard fish, the bones of which being perfectly burnt, fell to pieces upon attempting to take them up; and by the account of the inhabitants on the coast of St. Michael's, great numbers of fish had been destroyed during the early part of the eruption, as large quantities, probably suffocated or poisoned, were occasionally found drifted into the small inlets or bays.

The island, like other volcanic productions, is composed principally of porous substances, and generally burnt to complete cinders, with occasional masses of a stone, which I should suppose to be a mixture of iron and lime stone.

SECTION V.

MIXED PHENOMENA.

New Island formed in the Bay of Bengal.

20. A new island has been lately formed in the upper part of the Bay of Bengal, by a rapid accretion of the alluvion or soil, made along the shores of the large rivers of the Indian continent. The island is nothing at present but a sand-bank; but it is continually receiving such additions as will gradually render it a spacious tract. It was not visible four or five years ago, and it was only discovered, together with the canal, by vessels trading to Saugur, about the latter end of 1816.

The situation is 21° 35′ of latitude, and 88° 20′ of longitude east of Greenwich. This position is precisely that which has been indicated in the maps as the bank of Saugur, at the eastern extremity of the upper part of the island of that name. Its formation between the mouths of the Flougly and the canal of the bay, may well enough account for its origin. There being two considerable mouths of rivers, with rapid currents rushing into the sea, both east and west, these must have long been a submarine agglomeration, which has now risen above the surface of the ocean, and must increase under the protection of the continental lands that lie between those two arms of the Ganges.

This island (which has been named Edmonstone,) is about two miles in length from east to west, and half a mile wide from north to south. At the western extremity are little elevations that command a view of the sea. The centre of the island rises high enough to afford shelter, except during the violence of a tempest. The southern shore consists of a fine but solid sand, with a gentle declivity; one of its bays lies very convenient for sea bathing.

The north coast is much intersected with bays and long slips of land, which, with other accretions that appear at low water, form a line of soil in the middle of the canal, that separates the island from Saugur. This canal is about four or five miles wide but very shallow; there is every reason to conclude, that in a few years, it will be completely stopped up and that the Isle of Edmonstone will compose the southern extremity of the continental peninsula.

Situations like this form a proper subject of speculation for the philosophic mind, to trace the progress of such a soil, in raising a substratum that will hereafter furnish subsistence for animals and vegetables.

Here the operations of nature are in their infancy, a growing assemblage, consisting of alluvions, trunks, branches, and leaves of trees, with seeds, and other materials, brought by the winds and waves from the opposite coast, and finally deposited by the reflux. They may be seen floating in immense masses in the canal, and may be considered as tributary offerings to the new creation. The quantity of wood conveyed hither in this manner is so considerable, that some of the barges that bring fuel from the Sunderbunds prefer touching at the Isle of Edmonstone, to load with the fragments that lie scattered there. The wood and the leaves become decomposed by time, and furnish a supply of soil proper for vegetation. As to the seeds, they appear to retain their vital quality, and will grow spontaneously in the sands, wherein even branches will occasionally take root.

In some parts the island is covered with the dung of birds, which becomes manure for the soil. Myriads of small crabs cover the northern coast, and their visits are productive of some utility.

The central part of the island looks at a distance like a green lawn, dazzling to the view: herbage has taken root here, and there are a number of tufts of long *cass* (*saccharum spontaneum*) that thrive very well. Several little trees and shrubs are also visible, among which are the *date manhy*, and profuse scatterings of the *aal* or morinda, the large grains of which are of a triangular form. There is a pretty large quantity of purslain, (*portulacca oleracea;*) also a kind of bean.

But the principal plants, and indeed the principal contributors to the whole formation, are the *ipomea* or *pes capræ*, and the *salsola;* both are found in great abundance. The former appears to be in a soil exactly suited to it, and throws a prodigious lustre on the centre of the island.

A number of creeping plants strike deep roots into the sand, and, spreading several yards over the surface of the soil, help to keep the sand cemented; a new layer of sand coming over this, the shoots pierce through and cover it again, so that it is no longer at the mercy of the winds. There is a progressive accumulation of these roots, which ramble in all directions; new branches are constantly crossing each other, so as to form a compact sort of lattice-work: thus the sand becomes a solid aggregate, and capable of retaining the fresh layers that spread over it.

In short, the soil has every appearance of becoming well adapted for all the purposes of vegetation; and there can be little doubt that what is now the sandy base of the Isle of Edmonstone, will hereafter contain produce like the neighbouring islands and continent.

At present the island is only visited by wood-cutters and fishermen, who have raised two huts on it in honour of Siva, an Indian divinity and the third person of their Trinity. There is no vestige of any other habitation. The canal that separates the island from Saugur is well stocked with fish of different descriptions; and the southern shore is frequented by tortoises.

Sinking of a Hill in the State of New York.

21. On the 1st of June, 1796, a remarkable phenomenon occurred in the vicinity of the town of Katskill, in the State of New York. The country in the neighbourhood is a succession of little hills, or rather small elevations, detached from each other, and only connected a little at their bases. One of these hills, the nearest to Katskill Creek, and elevated about 100 feet above the level of the creek, suddenly suffered a sinking of more than half its declivity. It might have measured about 150 feet, from its summit to the extremity of its base, following the line of inclination. A breadth of about eighty fathoms fell in, beginning at about two or three fathoms from the top. The sunken part gave way all of a sudden, and fell so perpendicularly that a flock of sheep feeding on the spot, went down with it without being overturned. The trunks of trees that remained on it in a half rotten state, were neither unrooted nor even inclined from their former direction, and now stand at the bottom of this chasm, of above four acres in extent, in the same perpendicular position, and on the same soil. However, as there was not sufficient space for all this body of earth, which before had lain in a slope, to place itself horizontally between the two parts of the hill that have not quitted their station, some parts are cracked, and as it were furrowed.

But a more striking circumstance is, that the lower part of the hill, which has preserved its former shape, has been pushed and thrown forward by the sinking part making itself room; that its base has advanced five or six fathoms beyond a small rivulet, which before flowed at the distance of above ten fathoms from it; and that it has even entirely stopped the course of its stream. The greatest elevation of the chasm is about fifty or sixty feet; in its sides it has discovered a blue earth, exhibiting all the characteristics of marl. In some of the strata of the marl is found sulphate of lime in minute crystals. The sinking of the hill made so little noise, as not to be heard at the proprietor's house at the distance of 300 fathoms, nor at the town, which is separated from the hill only by the narrow stream of the creek.

Subterranean Lakes.

22. In the canton of Bresse, in Burgundy, there are two subterranean lakes, which often overflow in times of the greatest drought, and lay a large tract of ground under water; one of them has no apparent spring or opening, and yet in a dry season it throws out water enough to overflow the meadow-land near it. The grottoes or caves of Arcy are seated about eighteen miles from Auxerre, and over them is soil about ten feet deep. The entrance into these caves is 200 paces long, but narrow.

There are arches which form several vaults, from whence drops clear water, which turns into a brilliant hard stone. Twenty paces from the entrance is a lake, which seems to be formed by that part of the water that will not petrify. The highest of the vaults is not above eight feet. About eighty paces from the entrance there is a kind of hall, with a coffee coloured ceiling, wherein there are a thousand odd figures, which have a very agreeable effect.

SECTION VI.

NATURAL BRIDGES, &c.

Natural Bridge in Virginia, North America.

23. This bridge is described by Mr. Jefferson in his State of Virginia. It commences at the ascent

of a hill, which seems to have been cloven asunder by some convulsion of nature, the fissure at the bridge is by some measurements said to be 270 feet, by others only 205; width at bottom forty-five feet, at top ninety, which gives the length of the bridge; the thickness at the summit of the arch is forty feet; a considerable part is of earth, upon which grow many large trees, the residue is of the same materials with the hill on both sides, which is a solid lime-stone rock, and forms the arch, which is of a semi-elliptical form, very flat.

The height of this arch above the water (the whole being 205, and forty the thickness) is 165 feet, the breadth at the middle is about sixty feet. It has no ledges, but what is formed on some parts by the rock, but even at these few can stand upon their feet to look down, but go on hands and feet to peep over. On the contrary, the view from below is most delightful, and enchanting. The fissure continuing narrow and straight, both above and below, and of such height that it exhibits a prospect for about five miles; gives a short but very pleasing view of Blue Ridge on the one side, and North Mountain on the other; the stream that passes below it, is called Cedar Creek, and falls into James's river. The bridge is in the county of Rockbridge, to which it has given the name. We have no account of the time when it was produced. It has, however, formed a passage between two mountains otherwise impassable.

Natural Bridge of Angaraez, South America.

24. This bridge is described by Don Ulloa. It is from sixteen to twenty-two feet wide, 111 feet deep, of breadth 1⅓ of a mile, and is not sensibly greater at top than at bottom. Don Ulloa thinks it has been effected by the wearing of the water which runs below it; if so, it would have worn down plain and smooth, or most on that side on its descent, where the rock was of softer materials; but he informs us that the cavities on the one side, were equally hard, and tally with protuberances of the other, that if they met they would fit in all their

indentures so as to leave no space void; from which we are rather inclined to conclude, that it has been formed by some violent convulsion of nature.

In comparing the two, although we find in the bridge in Virginia, the same quality of rock on both sides, and with the bridge itself, we do not find the protuberances on the one side answering to the cavities of the other; if any such have been, the protuberances must have been effaced by time.

Causes of the Crystalline Forms of Minerals.

25. The great variety of forms which the same mineral species is known to assume, has drawn much of the attention, and occasioned the most laborious part of the investigations of mineralogists. The known forms of calcareous spar exceed 600; and perhaps those of iron pyrites and of some other species, if they were fully examined, would not be found much fewer. Leblanc was the first modern chemist that attempted to account for this diversity; but the progress which he made was inconsiderable. The subject has lately been taken up by M. Beudant, who has published a most interesting and elaborate paper on the subject, the substance of which is as follows:

1. The state of the atmosphere, the greater or less rapidity of evaporation, the form of the vessel, its nature, the quantity of liquid, the state of its concentration, seem to have no effect whatever upon the crystalline forms which salts assume; they merely influence their beauty and size.

2. When the atmosphere is moist, the salts have a tendency to form crystalline vegetations on the edges of the vessel.

3. Very dilute solutions, excluded from the air and prevented from evaporating, may yield crystals after a longer or shorter interval of time. But this is particularly the case with those salts which have but little solubility.

4. The nature of the vessels, by exercising different attractions on the salts, occasions the crystals to deposit themselves more or less quickly, and to accumulate in different ways in different parts of the solution. If the vessels are covered with a coat of grease, the crystallization takes place only at the surface.

5. The position in which the crystals are deposited in the midst of a liquid mass, has no other influence than that of producing more or less extension of the crystal in one direction, rather than another. The bounding faces are always of the usual number, and in the usual position.

6. The temperature and electrical state seem to have no influence on the forms of crystals; excepting that at high temperatures crystallization is very irregular, and the saline masses produced are very fragile.

7. Substances in suspension, almost permanent in a saline solution, have no effect in varying the crystalline form. These substances are often deposited in the crystal in concentrated layers.

8. The crystallization of a salt cannot take place in the midst of a deposit of foreign matters in very fine and incoherent particles, unless the deposit be covered to a certain height by the liquid. Crystals, formed in these circumstances, always contain a portion of the foreign matters which are found disseminated more or less regularly in their mass, and never deposited in concentric layers. When the solution is not much concentrated, the crystals are always of a simpler form and more regular than when they are crystallized in a pure liquid. When the solution is very concentrated, isolated crystals are formed in it, whose faces are crossed like the hopper of a mill.

9. The crystallization of a salt may take place in the midst of a gelatinous mass without the necessity of any supernatant liquid. In that case the crystals contain none of the foreign matter, and undergo no change of form; but they are almost always isolated and remarkably regular and complete in all their parts.

10. When several salts are in solution in the same liquid, it would appear that they are capable of mutually affecting one another's crystallization, even when they are not susceptible of uniting or acting chemically upon each other. Thus common salt takes the form of a cubo-octahedron when it crystallizes in the midst of a solution of borax, or still better of boracic acid.

11. The forms which the same salt is capable of assuming, vary according to the nature of the liquid from which it is precipitated. Thus alum assumes the cubo-octahedral form when it crystallizes in nitric acid, and the cubo-icosahedral form when it crystallizes in muriatic acid.

12. Whenever several salts are capable of mixing chemically, that is to say, of uniting without entering into a definite combination, that salt, whose system of crystallization predominates, always assumes particular forms which differ

from those which it adopts when it is pure. The different salts present likewise in general, different forms in the same system of crystallization, according as they contain more or less of acid; and the double salts according as one or other of the component salts exist in more or less quantity.

13. The chemical action which tends to determine a particular form, by altering the composition of a salt, produces different effects according to its energy, and often gives occasion at once to several varieties of crystals. Thus the action of an insoluble carbonate upon alum determines in the same solution octahedral crystals, cubo-octahedral crystals, cubic crystals, and an incrystallizable matter which contains still less acid than the preceding.

14. When simple crystals of different forms belonging to the same salt are dissolved together in the same liquid, two different things may happen. If the crystallization takes place slowly, the crystals are deposited in succession and separately; but if the crystallization be rapid, a single mixed compound is formed, exhibiting crystals partaking at once of all the different simple forms. The octahedral and cubic crystals of alum may unite and constitute cubo-octahedral crystals.

15. Crystals of complex form may be sometimes decomposed into several simple forms by different solutions and successive slow crystallizations. Thus, cubo-octo-dodecahedral alum yielded separate octahedrons, cubes, and cubo-dodecahedrons.

16. Crystals of a certain form being put into a solution of the same substance, which gives naturally a different form, encrease by additions according to this new form.

The Giant's Causeway.

26. The Giant's Causeway in the county of Antrim in Ireland, is the most remarkable one of its kind in the world. The name of it may naturally convey to us the idea of some stupendous work of art; and as such it seems to have been considered in the days of ignorance, when the name was first applied; modern philosophy, however, looks on it with a different eye. To conceive a proper idea of this unparalleled curiosity, we may imagine an approach to it from the sea: its first appearance is that of a bold rocky shore, with extensive ranges of shelving,

calculated for an immense promenade. These rocks, however, instead of being disposed in laminæ or strata, form basalts or angular columns, so closely attached to each other, that, though perfectly distinct from top to bottom, scarcely any thing can be introduced between them.

The columns themselves are not each of one solid stone in an upright position, but composed of several short lengths exactly joined, not by flat surfaces, as in works of art, but, what is most extraordinary, they are articulated into each other, as a bone is into its socket, the one end of the joint having a cavity into which the convex end of the opposite is exactly fitted : which is not visible but by disjointing the two stones. The depth of the concavity is generally from three to four inches ; and what is still further remarkable, the convexity and the corresponding concavity are not conformed to the external pentagonal figure of the column, but exactly round, and as large as the size of the column will admit. It is still further remarkable, that the articulation of these joints are frequently inverted. In some the concavity is upwards, in others the reverse.

The formation of this curious natural production has been accounted for by supposing that the whole body of the rock was once in a state of fluidity, being no other than the lava of a burning mountain; that the prodigious mass cracked in its cooling into the forms which we now see; that it may since in some measure have been deranged by earthquakes; that these have swallowed up the volcano itself; and that the waters of the neighbouring ocean now roll over the place where it once stood. Those geologists, however, who have embraced the system of Werner, attribute all these effects to the agency of water.

EXTRAORDINARY CAVERNS.

Immense Caverns in Ireland.

27. The vastly extensive caves of Ballybunnion, in the county of Kerry, are highly deserving of examination. Several of these immense caverns are as yet unexplored, and their inspection would make ample remuneration for the trouble of obtaining

access to them. They are surrounded by the most beautiful and romantic scenery, situated in the bosom of a country whose shores are washed by the waves of the vast Atlantic—the proudly towering cliffs give a grand and majestic appearance to this enchanting scene, the prospect from the summit of which exceeds the most glowing description; no just idea can be formed, even by imagination, of this singularly beautiful spot. On either side, a rich and vernal green delights the sight, on one a fruitful and well cultivated country; and on the other, the heaving bosom of an immeasurable ocean, whose billows dash against its beach. Wave chasing wave, in quick succession, display the grandest and most magnificent exhibition of natural curiosities; and the tremendously terrific roar is returned by ten thousand echoes from the clefts and hollows in the adjacent rocks. Descending from this charming eminence, the next moment entombs the delighted observer in the bowels of the earth.

The entrance to these caverns is at first easy, but afterwards attended with some difficulty on account of the projections of the rocks at either side; and the particles which time or some sudden convulsions of nature had removed from their situations, intercept the path.

Several of these subterraneous grottoes form the most splendid chambers, and the effect produced by a lighted flambeau is indescribably beautiful; the roofs, ceilings, and floors, are of a brilliant and transparent crystal, pieces of which are preserved by naturalists with the most pious care, and some of them have declared it superior to the celebrated Derbyshire spar.

The discharging of fire arms, much practised in caves, is here attended with danger, immense fragments of rock being frequently dislodged by the sudden report. Sounding a bugle or a trumpet has a pleasing effect, and is considerably safer; the tones are reverberated with a most agreeable multiplication, until they "in hollow murmurs die away."

The caves are of great magnitude, and the passage, from the entrance to an excavation at the mouth of the bay, is about three miles, which is perfectly passable.

Cavern near Shahpoor.

28. In September 1816, Mr. Williams and Captain Maude, of the ship Favourite, having visited the site of the ancient city of Shahpoor, in the province of Fars (the ancient Parais) accompanied by Meer Shumsoodeen, a predatory chieftain, who from his plundering mode of life, had become well acquainted with the hidden recesses of the mountains, pointed out to their notice an extensive cavern containing a prostrate colossal figure.

The cave is distant from Shahpoor three miles, on the opposite side of the river. From the base of the mountain, near the summit of which the excavation is made, no traces of a cavern are discernible. The ascent is difficult, chiefly from its perpendicular height. When the travellers had nearly reached the top, they found themselves at the foot of an abrupt rampart, about thirty feet high, the depth of which, from its upper edge to the entrance of the cave to which it forms a level landing, was sixty feet. The entrance to the cavern is a plain, roughly hewn arch, three feet high, and thirty-five feet wide, beyond which the height increases to forty feet, and the width to sixty and seventy.

The figure, which is of stone, appears to have stood originally on a pedestal in the middle of this excavation, but was discovered lying on the ground, and the legs below the knees broken off. The costume appears to be similar to the sculptures at Shahpoor, Nukshi, Roostum, and Persepolis, and with the same luxuriant flow of curled hair. Its arms rest upon the hips, and the costume is a robe, fastened by a small button at the neck, and falling loosely over the elbows, and in this respect differs from the sculptures just mentioned. The length of the face from the forehead to the chin is two feet three inches, and the length of the body four feet and a half. According to this measurement the whole figure must have been about fourteen feet high. From the statue, to the most retired parts of the cavern, the excavation increases in height and width. After passing down an inclined plane, for about twenty feet, and up an ascent of about fifty feet more, the travellers reached a dry reservoir, seventeen feet by seven wide, and five feet deep. Farther on, they began to descend by torch light a low narrow passage in the rock, and reached another cavern, the roof of which was supported by a few huge shapeless pillars. The use or object of this excavation is not known.

SECTION VII.

CORALLINE STRUCTURES AND PETRIFACTIONS.

The arrangement of these subjects under one head is less material than the contrast they form, and the reflections to which they lead. On these grounds we have classed as first in this section

Zoophytic, or Coralline Structures.

29. M. de Perssonel of Marseilles, made some experiments on coral and other marine bodies. These bodies, which the Count de Marsigly imagined to be flowers, this ingenious naturalist discovered to be insects, inhabiting the coral. M. Donati, of Turin, says, that coral is a mass of animals of the polype kind; and, instead of representing the polype beds and cells, which they contain, as the work of polypes, he thinks it more just to say, that coral and other coralline bodies, have the same relation to the polypes united to them, as there is between the shell of a snail and the snail itself; or the bones of an animal, and the animal itself. The same system has also been illustrated and established by Mr. Ellis.

The Red Sea, the Indian and Pacific Oceans, abound with coral. Throughout the whole range of the Polynesian and Australasian islands, there is scarcely a league of sea unoccupied by a coral reef or a coral island; the former springing up to the surface of the water from the fathomless bottom: and the latter, in various stages, from the low and naked rock, with the water rippling over it, to an uninterrupted forest of tall trees. "I have seen," says Mr. Dalrymple, (in his Inquiry into the Formation of Islands,) "the coral banks in all their stages, some in deep water, others with a few rocks appearing above the surface, some just formed into islands, without the least appearance of vegetation; others, with a few weeds on the highest part; and, lastly, such as are covered with large timber, with a bottomless sea, at a pistol-shot distance." In fact, as soon as the edge of the reef is high enough to lay hold of the floating sea wreck, or for a bird to perch upon, the island may be said to commence. The dung of birds, feathers, wreck of all kinds, cocoa-nuts, floating with the young plant out of the shell, are the first rudiments of the new island. With islands thus formed, and others in the several stages of their progressive creation, Torres Strait is nearly choaked up; and Captain Flinders mentions one island in it covered with the casuarina, and a variety of other trees and shrubs, which give food to paroquets, pigeons, and other birds, to whose ancestors, it is probable, the island was originally indebted for this vegetation. The time will come, when New Holland, New Guinea, and all the little groups of islets and reefs to the north, and north-west of them, will either be united into one great continent, or be separated only with deep channels, in which the strength and velocity of the tide may obstruct the silent and unobserved agency of these insignificant labourers.

A barrier of coral reef runs along the whole of the eastern coast of New Holland; among which (says Captain Flinders,) we sought fourteen days, and sailed more than five hundred miles, before a passage could be found through them out to sea.

Supposing the sea were to change its bed, and to cover again the present continents (as it most probably will,) what great ranges of hills and mountains will then appear the work alone of diminutive insects! And, if the present islands and continents were once, for a series of ages, covered by the sea, (as the generality of the present geologists believe they were,) did these little polypes work in that sea! If they did, where are their works? Is it now lime-stone and chalk?

30. The chalk hills of Dorset have nearly the same appearance as would the coast of New Holland, were the sea to forsake its bed, and leave the foundation of the coral reefs dry, after the atmosphere and the rains had decomposed and pulverized their upper parts, and the debris had tumbled down their sides; and were the sea again to fill our vallies, ships would find no anchorage at a pistol-shot distance from the sides of our chalk hills, as is the case near the reefs of coral.

It cannot positively be said that chalk was formed by the coral insects; but many observations tend to inculcate that belief. The chalk is incumbent on a stratum of sand-stone, full of shells, which was once the bottom of the sea, before the chalk was formed; the sand-stone rests on a bed of sand, with a few shells: a little above the sand-stone, in the chalk, we find *cornua ammonis*; and it was easy for them to find their way there, when the reef had just begun forming. Higher up in the chalk, few shells are found, and generally single specimens. A stratum of flints is generally found in chalk; but that may be accounted for by atoms of silica being at first mixed with the calcareous matter, and, in course of time, joined by the force of attraction,—as atoms with kindred atoms join. In the alluvial formation, on the banks of the Ohio, near Cincinnati, different species of coralline are found, generally calcareous, now and then siliceous: the siliceous matter must, therefore, have entered, and displaced the calcareous, whilst in a dissolved state. We frequently find shells inclosed in flints: the flinty matter must have been once in a soft state, as the flint exhibits the exact form of the shell which it surrounds. The lime-stone formation, on the banks of the Ohio, is thought to be the largest lime-stone formation in the world, it is likely to be also the work of the marine polype.

Formation of Strata at the Bottom of the Ocean.

31. Solid materials are successively created upon the bottom of the ocean, where they do not perish, but accumulate in extremely large quantities. An examination of the strata of this planet, made with tolerable attention, would discover them to amount at this time, to about 7,700 feet, which is little less than one mile and a half in thickness, measuring from the surface to the formation of the slate stratum only.

The upper layers of all strata are softer than those which lie below; the greater degree of infiltration and compression which the lower strata have undergone, has rendered them more compact and hard; and such parts of the layers as lie within the influence of the atmosphere are in a state of decomposition. Much of such strata as contain fragments of marine shells have the appearance of being formed, partly by a new creation, and partly by a new arrangement of the old materials of land destroyed.

The then newly-created part is the natural produce of shell-fish and corals; the new arrangement is also the natural result of the cliffs along the coasts of all land being washed down, beat to pieces, and spread over the bottom of the ocean, the operation of spreading the earthy materials of former land over the bottom of the ocean, would generally put shell-fish to great inconvenience, and frequently bury some of them alive, when they would contribute towards the formation of new strata. These loose earthy materials, mixed with the shells of fish and corals, buried in vast numbers, both dead and alive, and in every state of comminution, would then be subjected to infiltration, and the natural compression of a continued augmentation of similar materials, as well as of super-imposed strata; all these things, continued for a very long time, have changed the loose materials into strata, and such seems to have been the origin of all marl, chalk, lime-stone, and even marble.

All strata contain proofs in abundance that their creation took place in a very slow and gradual manner, whereof the lowest layer of slate is bedded upon either quartz or granite, and all the rest have been added in succession; *stratum super stratum*, from the quartz or granite upwards to the surface. A very considerable proportion of these strata have unquestionably been created by the inhabitants of the ocean, though it must be admitted that some of the local strata (coals for instance) have had a vegetable origin; but the ocean has had the most important share in arranging these things.

Our knowledge of the structure of this planet is mostly confined to what we discover by an examination of its strata; and these prove that, with the exception of coal, they are generally a marine production. Of this any person may satisfy himself, who will undertake the trouble of examining them in their natural situation, and view the specimens of mineralogy in the several museums, for in these places, the proofs are before us. The strata of this planet have been examined from the surface downwards to the depth of about two miles, and the whole of that depth consists of *stratum super stratum*; and they show, in a way which cannot be controverted, that they have been formed one after another, successively, from a great depth to the surface; or, in other wards, the strata of greater depth, were formed more early than such as lie upon them.

It is supposed to be well understood, or satisfactorily proved, that the work of creation began at the centre of the planet; if so, all, or nearly all, the subsequent formation is not more than could be accumulated by gravity and the motion of water, aided, immensely aided, by such apparently feeble creatures as shell-fish and corals; as it is now known that the component parts of the several strata mostly consist of sea-shells and coral, the products of animals who must have lived and died during the time the several strata were forming.

From very early times, these creatures have abounded at the bottom of the ocean, and they still continue to abound there; nay, they may be supposed to cover it; their naturally very great increase is calculated to have a vast effect, particularly, as on the extinction of life, their exuviæ are placed in a situation which renders them nearly, or quite, imperishable.

The shells and the corals continually accumulate upon each other, and they have actually accumulated until they have formed strata of very great thickness; this could only have been done by the ordinary generation and death of the animals, and it is obvious that this operation is so slow as to require an immeasurably long time to form strata of very great thickness.

That strata, consisting in a very considerable degree of the shells of fish and corals mixed with sand and various sorts of earth, placed by the ocean where we find them, have accumulated to a thickness of two miles, is supposed to be incontrovertible; therefore our next inquiry should be, in how many years could this be done? This accumulation has been supposed to take place at the rate of about a foot in one hundred years. Two miles are 10,500 feet, and that number, multiplied by 100, produces 1,056,000 years, as the time in which these animals, aided by the waves of the ocean, may have accomplished that vast work.

Petrified Trees.

32. On the south bank of the river North Esk, a

short distance above the paper-mill at Penicuik, near Edinburgh, where the strata usually accompanying the coal formation of this country are exposed, a large portion of the trunk, and several roots, of a fossil tree, are visible. It rises several feet above the bed of the river, as far as the strata reaches, and the roots spread themselves in the rock.

It appears as if the tree had actually vegetated on the spot where we now see it. It is, where thickest, about four feet in diameter. The strata, in which the remains of the tree stand, are slate clay, and the tree itself is sand-stone. There is sand-stone below and immediately above the slate clay, and the roots do not appear to have penetrated the lower sandstone, to which they reach. Small portions of coal were observed where the bark existed, the form of which is distinct on the fossil.

33. Whilst sinking a pit, in 1818, at Mr. Fenton's colliery, near Wakefield, Yorkshire, the workmen, having dug to the depth of eighty-six yards, came to a bed of coal two feet six inches thick, beneath which they found a petrified tree, or rather plant, having no branches, standing upright, but rather inclining to the east. It was six inches diameter at the top; but, as they sunk down, it increased to twelve inches, and at the depth of forty-two feet, seemed to branch out roots to another bed of coal six feet thick.

The body was a grey sand-stone, coated round with a black carbonized matter one-tenth of an inch, supposed to be its bark.

A species of siliceous fossil wood, was found by a serjeant of artillery, who accompanied Captain Sabine, near the top of a hill in Hare Island, on the west coast of Greenland, in latitude 70° 26′. It had been a part of the trunk of a pine tree, about four inches in diameter. The hill is in the interior of the island, about four miles from the shore, and is considerably more than 900 feet above the level of the sea.

34. The situation of the petrified trees found in Russia, which, separated from their stumps, are found sometimes as much as fourteen feet under ground, chiefly in marshes, proves that they were overturned

by violence, and prostrated in the spots where they formerly stood erect.

The bed of earth which covers them consists of sand and clay. Under dry sand, the wood is reduced to dust; but the form of the tree remains visible, if the dust be removed carefully. Under wet sand, the wood is found perfectly sound, with however a blackish colour. Only large oaks appear to have been torn up by the roots. The trees which are partly petrified, are found chiefly under a bed of potter's clay. The oaks which have not been petrified, on being exposed to the air, harden considerably. It is remarkable, that these trees are frequently found in grounds where none of the sort now grow. Professor Kunizyn imagines, that these trees were thus prostrated and covered with earth by the same violent motion of nature, which, in the north of Russia, separated enormous masses of granite from their foundations, and carried them to a considerable distance.

35. Mr. W. Chapman has communicated to the Royal Society, an hypothesis, that coal is derived from the prolonged compression of beds of peat.

The deepest peat-bogs are from thirty to forty feet; and he finds, by calculation, that, if this mass was compressed, it would be about equal to the strata of coal at Newcastle. He also traces the analogy between the timber or trees found in peat-bogs, and on the sea-shores of Northumberland, and the grit-stone found in the Canton mine at Newcastle. This stone, specimens of which have been sent to the British Museum, has the perfect form and appearance of trees; and even its apparent fibres are such as to leave no doubt of the kind of wood which had preceded the present sand or grit. The combustion which assisted the change of peat into coal, he considers as having been effected by means of the pyrites.

Account of the Mammoth, or fossil Elephant, found in the Ice at the Mouth of the River Lena, in Siberia.

36. Mammoths' and elephants' bones and tusks are found throughout Russia, and more particularly in Eastern Siberia and the Arctic marshes. The tusks are found in great quantities, and are collected for the sake of profit, being sold to the turners in the place of the living ivory of Africa, and the warmer parts of Asia, to which it is not at all infe-

rior. Towards the end of the month of August, when the fishing season in the Lena is over, the Tungusians generally go to the peninsula of Tamut, where they employ themselves in hunting, and where the fresh fish of the sea offer them a wholesome and agreeable food.

One day, their chief, Schumachof, perceived among the blocks of ice a shapeless mass, not at all resembling the large pieces of floating wood, which are commonly found there. The following year (1800) he found the carcase of a walrus (*trihchechus rosmarus.*) He perceived, at the same time, that the mass he had before seen was more disengaged from the blocks of ice, and had two projecting parts, but was still unable to make out its nature. Towards the end of the following summer (1801,) the entire side of the animal, and one of his tusks, were quite free from the ice. But the summer of 1802, which was less warm, and more windy than common, caused the mammoth to remain buried in the ice, which had scarcely melted at all. At length, towards the end of the fifth year (1803,) the ardent wishes of Schumachof were happily accomplished; for the part of the ice between the earth and mammoth having melted more rapidly than the rest, the plane of its support became inclined, and this enormous mass fell, by its own weight, on a bank of sand.

In the month of March, 1804, Schumachof came to his mammoth; and, having cut off his horns (the tusks) he exchanged them with the merchant Bultunof for goods of the value of fifty rubles.

Two years afterwards, a Mr. Adams, traversing these distant and desert regions, found the mammoth still in the same place, but altogether mutilated. Wild beasts, such as white bears, wolves, wolverines, and foxes also fed upon it; and the traces of their footsteps were seen around. The skeleton, almost entirely cleared of its flesh, remained whole, with the exception of one fore-leg. The spine from the head to the oscoccygio, one scapula, the pelvis, and the other three extremities, were still held together by the ligaments, and by parts of the skin. The head was covered with a dry skin; one of the ears, well preserved, was furnished with a tuft of hairs.

All these parts have necessarily been injured in transporting them a distance of 7,330 miles; yet the eyes have been preserved, and the pupil of the left eye can still be distinguished. The point of the lower lip had been gnawed, and the upper one, having been destroyed, the teeth could be perceived. The brain was still in the cranium, but appeared dried up.

According to the assertion of the Tungusian chief, the animal was so fat and well fed, that its belly hung down below the joints of the knees. This mammoth was a male, with a long mane on the neck, but without tail or proboscis. The skin is of a dark grey colour covered with a reddish wool, and black hairs. The dampness of the spot where the animal had lain so long, had, in some degree, destroyed the hair. The entire carcase was ten feet high, and seventeen long, from the point of the nose to the end of the tail, without including the tusks, which together weighed 360 pounds. The head alone, without the tusks, weighed 414 pounds. The place where he found the mammoth, is about sixty paces distant from the shore, and nearly 100 paces from the escarpment of the ice from which it had fallen. This escarpment occupies exactly the middle between the two points of the peninsula, and is two miles long. The skeleton is now in the Museum of the Academy of Petersburg, and the skin still remains attached to the head and the feet.

The preservation of the flesh of the mammoth, through a long series of ages, is not to be wondered at, when we recollect the constant cold and frost of the climate in which it was found. It is a common practice to preserve meat and berries through the winter by freezing them, and to send fish, and all other provisions, annually at that period, from the most remote of the northern provinces, to St. Petersburg, and other parts of the empire.

37. In 1817, Dr. Mitchell assisted in disinterring the remains of a mammoth, at Chester, fifty-four miles from the city of New York, about a year ago. Since that time, the remains of another individual of this species have been found in a marsh, only thirty-two miles north. He also discovered another in the town of Goshen, Orange County, within sixty miles of New York, in a meadow belonging to a Mr. Yelverton. The soil is a black vegetable mould, of an inflammable nature. It abounds with pine-knots and trunks, and was, about thirty years ago, covered with a grove of white pine-trees. The length of the tooth was six inches, the breadth

three and a half inches; the circumference of the lower jaw, including the tooth it contains, twenty-six inches; the length of the jaw, thirty-five inches.

38. In the same year were discovered in the parish of Motterton, in the Isle of Wight, bones which are supposed to belong to one of these stupendous animals. Several of the vertebræ, or joints of the back-bone, measure thirty-six inches in circumference: they correspond exactly in form, colour, and texture, with the bones found on the banks of the Ohio in North America.

Also, in the parish of Northwood, on the north side of the island, the bones of the crocodile have recently been found by the Rev. Mr. Hughes of Newport. They seem to have belonged to an animal of that species, whose body did not exceed twelve feet in length. Their calcareous nature is not altered; but the bones of the mastodon (found on the south side of the island) contain iron.

39. A considerable quantity of bones of a large size, were lately discovered buried in the earth, in the neighbourhood of the village of Tiede, near Brunswick. They were examined by M. Dahne, who appears to have distinguished parts of the skeletons of five elephants.

There were nine tusks among them, one of which was fourteen feet in length, another eleven, and many grinders, in which the enamel was arranged exactly as in the teeth of the African elephant. A complete head of a rhinoceros, with the horn and teeth, was also found very little altered, and likewise the horns of two kinds of stags. Mr. Dahne, in endeavouring to account for this accumulation of bones belonging to different animals, supposes that the animals existed in immense islands; that some great revolution of the globe inundated their habitations, and forced them to the highest spot for shelter from the waters; that, the waters still rising, they all perished together, that the perishable parts of their carcases were carried away by the waters, and that an earthy deposition soon enveloped the bones, and left them nearly in the state they are now found.

40. Accounts from the banks of the Mississippi state, according to Mr. Tilloch's Philosophical Ma-

gazine, that the mammoth has been discovered actually in existence in the western deserts of North America.

According to the descriptions given of it, this Colossus of the animal kingdom is not carnivorous, but lives on vegetables; more particularly on a certain species of tree, of which it eats the leaves, the bark, and even the trunk. It never lies down, and sleeps leaning for support against a tree. It has rather the shape of a wild boar than of an elephant, and is fifteen feet high. His body is covered by a hairy skin, and he has no horn.

Ships found imbedded in the Earth.

41. In the paper called the General Evening Post, for March the 17th, 1818, there is an account which has been lately received at the Admiralty, of an interesting discovery made in the south of Africa, about twenty miles north of Cape Town. Some persons, in digging, happened to strike upon what appeared a beam of timber; but, tracing it, they found a ship deeply imbedded in the soil.

A plank of it has accompanied the account of the discovery to the Admiralty. Several other ships, at different times, and in different parts of the world, have been discovered beneath the surface of the earth.

It is recorded by Fulgosas, that in the year 1462, as some men were working a mine near Berne, in Switzerland, they found a ship 100 fathoms deep in the earth, with anchors of iron, and sails of linen, and the remains of forty men.

Pairre Naxis relates a like history of another such ship having been found under a very high mountain.

The Jesuit Eusebius Newcombergus, in his fifth book of Natural History, says, that near the port of Lima, in Peru, as the people were working a gold mine, they found a ship, on which were many characters, very different from ours. Strabo also relates, in his first book, that the wrecks of ships have been found 375 miles from sea.

Dr. Plott, in his Natural History of Staffordshire, relates a story, that the mast of a ship, with a pulley hanging to it, was found in one of the Greenland mountains. Is it to be supposed that these ships, which have been found beneath the surface of the earth, were antediluvian ships? If they were, (and mankind knew the use of ships before the flood,) it is not probable that all mankind, except Noah and his family, would have been drowned by a deluge of waters.

Is it not more probable, that violent earthquakes, since the deluge, have been the means of swallowing up these ships? but the sea must, at that time, have covered that part of the land where they have been found.

In the year 1746, Calloa, a sea-port town in Peru, was violently shaken by an earthquake, and of 5000 inhabitants only 200 were saved. The sea rolled in upon the town in mountainous waves; ships of burden were conveyed over the garrison walls; and one ship, which arrived from Chili the preceding day, was conveyed to the foot of the mountains, and left on dry ground.

On the 7th day of June, 1692, the town of Port Royal, in Jamaica, was in two minutes totally destroyed by an earthquake: many ships were also swallowed up.

The earthquake which visited Sicily in 1693, shook the whole island, and extended to Naples and Malta; the city of Catania was destroyed, with 18,000 inhabitants: fifty-four cities and towns, besides many villages, were either greatly injured or totally destroyed. The city of Catania was rebuilt, and is now again in ruins by the late earthquakes that shook all Sicily. And on the first of November, 1755, Lisbon in Portugal was also destroyed by an earthquake: many ships in the harbour were also swallowed up, only their masts appearing above water: the sea suddenly rolled in like a mountain, ships were driven from their moorings, and tossed about with great violence. The same day that Lisbon was destroyed, Cadiz was violently shaken by an earthquake; and the inhabitants were yet more alarmed at the appearance of a wave coming towards the town at least sixty feet higher than common: it beat in the breast-work of the walls, and carried pieces of eight or ten tons weight forty or fifty yards from the wall, and passed over a parapet sixty feet above the ordinary level of the water.

St. Ubes, a sea-port town, twenty miles south of Lisbon, was entirely swallowed up by the repeated shocks of this earthquake: in Africa, near Morocco, the earth opened, and swallowed up a village with 8 or 10,000 inhabitants; Sallee and Tangiers also suffered greatly by an inundation of waters. The same earthquake was felt all over Spain: at Ayomonte, near where the Guadiana falls into the bay of Cadiz, the water came on in vast mountains, and laid under water all the coasts of the islands adjacent. The waters in many parts of Britain were greatly agitated at the same time. At three quarters after six in the evening, on the same day that Lisbon was sunk, and about the time of two hours' ebb of the tide, a great body of water rushed up in Glamorganshire in Wales, accompanied with great noise, and in such quantity that it floated two vessels of 200 tons burden each.

At Kinsale, in Ireland, a great body of water rushed with such violence into the harbour, that it drove two vessels from their moorings.

In Holland, the agitations were more remarkable: at Alphen, on the Rhine, the waters were agitated to such a violent degree, that buoys were broken from their chains, large vessels snapped their cables, smaller ones were thrown out of the water upon the land, and others lying on land were set afloat. This destructive earthquake extended over a tract of land of four millions of square miles.

History records a number of instances of great inundations of the sea on the land by earthquakes: the bottom of the sea is first elevated by means of subterraneous fires before the elastic vapours can find a vent; and the sea, of consequence, must flow over the land, the depth in proportion to the elevation of the bottom of the sea.

The master of an American vessel in north latitude 25°, at the time of the great earthquake, saw, from his cabin window, land about a mile from his ship; but, coming upon deck, the land was no more to be seen; and he perceived a violent current cross the ship's way to the leeward. In about a minute, this current returned with great impetuosity; and, at a league distance, he saw three craggy rocks throwing up water of various colours resembling fire; this phenomenon in about two minutes ended in a black cloud, which ascended very heavily: after it had risen above the horizon no rocks were to be seen. No doubt, but many ships have been driven far inland, and swallowed up by the earthquakes that followed the inundations of the sea, some of which, in course of time, may be accidentally discovered.

SECTION VIII.

MOUNTAINS, SPRINGS, &C.

As mountains are the usual source of springs, these subjects are accordingly classed under one head; but with regard also to their novelty and the singularity which both bear in comparison of the beaten tract so often trodden by compilers of various merits, we place first a description of

The Himmalayan Mountains.

42. The following relation and admeasurements are extracted from Mr. Fraser's and Lieut. Webb's notes, during excursions through these stupendous mountains.

The plains of Hindostan are bounded on the N.E. by a mountainous track which runs from the banks of the Burrumpooter to the Indus, and, crossing that river, spreads out into a less circumscribed and less high-land country, the chains of which are connected with many of the chief ridges of Asia. The belt of hills, which thus separates Hindostan from Thibet, is perfectly unconnected and running in irregular ridges, undivided by any valley of consequence from the one plain to the other. These mountains on the side of Hindostan, rise from a level at once into sharp and precipitous cliffs, while the north west side falls more gradually into green hills, and ends in a gently-sloping plain.

The great Himalaya mountains form the centre of this ridge, and rear their sharp crests, covered by eternal snow, to an almost incredible height, in unapproachable, desolate grandeur.

Jumnatra, the source of the Jumna, is estimated at 25,500 feet above the level of the sea.

The general line of the mountains between the rivers Bhagirutta and Sutlej, is nearly N. W. and S. E. A small abrupt ridge, rising from 500 to 750 feet in height, and extending from three to six miles in breadth, runs next to the plains from Hurdwar, half way to the Sutlej. This consists of sand-stone, indurated clay, and beds of rounded pebbles and gravel. The next range of hills runs from 1500 to 5000 feet in height, with sharp narrow crests, and consists of a very decomposable greyish brown indurated clay, containing siliceous matter. Just beyond this range rises a mountain of lime-stone, about 7000 feet high: a large perennial stream marks the division between this range and a mass of mountains consisting almost entirely of varieties of schist, with much mica, and veined with quartz. Connected with these, were observed a coarse sand-stone, and a conglomerate of sand, mica, and gravel, cemented by a white spar easily frangible. As the snowy mountains were approached, rocks of white quartz were observed, and of a hard semi-transparent stone of many colours, grey, red, yellow, and greenish. On reaching the heart of the snowy mountains, the distant peaks appeared to be stratified, and to dip to the N. E. at an angle of about forty-five degrees. For several thousand feet below their tops all vegetation ceases, and no living thing is to be seen. The returning route was for a considerable way along the bed of the river Pabur, which rises among the depths of the Himala: in this bed, blocks of a peculiar kind of rock were found. The neighbouring rocks were schist and lime-stone. Another opportunity presented itself of viewing the summits of the Himala from Jumnatree, which rises in two grand peaks, covered on the S. and S. E. by perpetual snow, but showing a precipitous rocky face towards the N. W. The river Jumna was here traced to its source in a number of small rills flowing from the snow, and collected in a pool at the bottom of a steep slope. Nearly every sort of rock observed throughout the tour was found here, particularly the rock before referred to as occurring in the bed of the river Pabur, and white quartz in veins intersected the general stratification. From these veins trickles a stream of hot water, impregnated with calcareous matter, which it deposits on the surface of the rocks over which it runs. There are no glaciers in any part of the snowy mountains; but a perpetual frost appears to rest on their summits.

These mountains exceed, in height, any before seen or heard of. There are in all, twenty-seven peaks, nineteen of which, as will be seen by the following statement, are higher than Chimborazo, (the highest mountain of the Andes in South America) which has been ascertained to be nearly 21,000 feet above the level of the sea. The highest of the Asiatic mountains, exceeds that of the American, by nearly 5000 feet. This mountain as will be seen by referring to the following admeasurements, (No. 14) carefully made by Lieut. Webb, is 25,669 feet high!!

Peaks.	Feet.	Peaks.	Feet.
1	22,345	15	22,419
2	22,058	16	17,994
3	22,840	17	19,153
4	21,611	18	21,439
5	19,106	19	22,635
6	22,498	20	20,407
7	22,578	21	19,099
8	23,164	22	19,497
9	21,311	23	22,727
10	15,733	24	22,238
11	20,686	25	22,277
12	23,263	26	21,045
13	22,310	27	20,923
14	25,669		

SECTION IX.

MISCELLANEOUS PHENOMENA.

Porousness of Bath Free Stone.

43. The Oolite, or freestone, found at Bath, is very soft and porous, is easily penetrated by, and absorbs a considerable quantity of, water. It has of late been formed into wine-coolers and butter-jars in place of the common biscuit ware, and, from the facility with which the water passes through it, so as to admit of evaporation at the surface, it succeeds very well.

But the most ingenious application of this stone is in the formation of circular pyramids, having a number of grooves cut one above the other on its surface; these pyramids are soaked in water, and a small hole made in the centre filled; salad seed is then sprinkled in the grooves, and, being supplied with water from the stone, vegetates; and, in the course of some days, produces a crop of salad ready to be placed on the table. The hole should be filled with water daily, and, when one crop is plucked, the seeds are brushed out and another sown.

Excavation in a Rock near Nottingham.

44. As some boys were amusing themselves in April, 1818, with digging in the rock at the back of Standard Hill, near Nottingham, they made a small opening therein, which they found to be the original entrance into a room, or cave, hewn in the solid rock.

Its dimensions are about eight feet by nine, with a rock bench or settle running round, the roof supported by a neatly wrought column of the same material, on which and the sides are several rude drawings, dates, initials, crosses, croslets fitched, and other devices,—the dates 1570, 1637, 1639, 1640. A rude oaken image, about five feet in length, was dug out of the sand on one side the entrance, and on each side is a narrow loop-hole.

That these relicts should be found in a subterranean chamber is not wonderful, but that living animals should exist pent up in the heart of rocks may well excite our astonishment.

Living Lizard found imbedded in a Seam of Coal.

45. In 1818, at Mr. Fenton's Colliery, near Wakefield, Yorkshire, a living lizard was found imbedded in a seam of coal.

This animal, preserved in spirits, is now in the possession of Mr. James Scholes, engineer to that colliery. It is about five inches long; its back of a dark brown colour, and appears rough and scaly; its sides of a lighter colour, and spotted with yellow the belly yellow, streaked with bands of the same colour as the back.

The miners were sinking a new pit or shaft, and after passing through measures of stone, grey bind, blue stone, and some thin beds of coal, to the depth of 150 yards, they came upon that intended to be worked, which was about four feet thick. When they had excavated about three inches of it, one of the miners, (as he supposed) struck his pick or mattock into a crevice, and shattered the coal around into small pieces; he then discovered the animal in question.

In sinking these pits the miners find, in particular strata, impressions of what Mr. S. calls ferns and other vegetables; and, at upwards of one hundred yards from the surface, they meet with a black shale, one foot thick, full of muscle-shells, compressed and flattened by the superincumbent pressure. About four inches above the coal in which the animal was found, numbers of muscle-shells, in a fossil-state, lie scattered in a loose grey earth.

Living Toads found inclosed in solid Stone.

46. Dr. Franklin is the narrator of the following singular circumstance.

In April, 1782, being with M. de Chaumont, at Passy, near Paris, viewing his quarry, he mentioned to me that the workmen had found a living toad shut up in the stone. On questioning one of them, he told us they had found four, in different cells, which had no communication; that they were very lively and active when set at liberty: that there was in each cell some loose, soft, yellowish earth, which appeared to be very moist. We asked, if he could show us the parts of the stone that formed the cells? He said no, for they were thrown among the rest of what was dug out, and he knew not where to find them. We asked, if there appeared any opening by which the animal might enter? He said no, not the least. We asked if, in the course of his business as a labourer in quarries, he had often met with the like? He said never before. We asked, if he could show us the toads? He said he had thrown two of them upon a higher part of the quarry, but knew not what became of the others. He then came up to the place where he had thrown the two, and finding them, he took them by the foot, and threw them up to us upon the ground where we stood. One of them was quite dead, and appeared very lean; the other was plump, and still living. The part of the rock where they were found is at least fifteen feet below its surface, and is a kind of lime-stone. A part of it is filled with ancient sea-shells, and other marine substances.

If these animals have remained in this confinement since the formation of the rock, they are probably some thousands of years old. We put them in spirits of wine to preserve their bodies a little longer. Before a suitable bottle could be formed to receive them, that which was living when we first had them, appeared to be quite dead and motionless; but, being in the bottle, and the spirits poured over them, he flounced about in it very vigorously for two or three minutes, and then expired.

It is observed that animals, who perspire but little, can live long without food: such as tortoises, whose flesh is covered with a thick shell, and snakes, who are covered with scales, which are of so close a substance as scarcely to admit the passage of perspirable matter through them. Animals that have open pores all over the surface of their bodies, and live in air, which takes off continually the perspirable part of their substance, naturally require a continual supply of food to maintain their bulk. Toads shut up in solid stone, which prevents their losing any part of their substance, may, perhaps, for that reason, need no supply, and being guarded against all accidents, and all the inclemencies of the air, and changes of the seasons, are, it seems, subject to no disease, and become, as it were, immortal.

Borax found in the Mountains of Thibet.

47. Borax, a salt well known in chemistry, is brought originally from the East Indies in an impure state, and afterwards freed from its impurities by certain processes in Europe. It was long a matter of uncertainty whether this salt be a natural or factitious substance in those countries from whence it is brought; but it is now beyond a doubt, that it is naturally produced in the mountains of Thibet, from whence other parts of the eastern continent are supplied. The place where it is found is said to be a small valley surrounded by snowy mountains, in which is a lake about six miles in circumference; the water of which is constantly so hot that the hand cannot bear it for any time. Around

this lake the ground is perfectly barren, not producing even a blade of grass; and the earth is so full of a saline matter, that after falls of rain or snow, it concretes in white flakes on the surface like the natron of Hindostan. On the banks of this lake, in the winter season, when the falls of snow begin, the earth is formed into small reservoirs six inches high: when these are filled with snow, the hot water from the lake is thrown upon it, which, together with the water from the melted snow, remains in the reservoir, to be partly absorbed by the earth, and partly evaporated by the sun; after which there remains at the bottom a cake of sometimes half an inch thick of tincal or crude Borax, which is taken up and reserved for use. It can only be made in the winter season, because the falls of snow are indispensibly requisite, and also because the saline appearances upon the earth are strongest at that time. When once it has been made on any spot, it cannot be made again on the same until the snow has fallen and dissolved three or four times, when the saline efflorescence will appear as before.

Elastic Marble.

48. In 1816, Dr. Mitchell exhibited to the New York Philosophical Society a specimen of American elastic marble, measuring four feet in length, three inches in breadth, and one inch in thickness. The slab was of a snowy whiteness, of a grained structure, and of remarkable flexibility. He had received it from the quarry in Pittsfield, Massachusetts. Since the receipt of this extraordinary sample, another one, of far more considerable size has been procured by Mr. Meyher, from Stockbridge. This he is preparing for Dr. Mitchell's Cabinet of Mineralogy. The dimensions of this stone are as follow: breadth, one foot and ten inches, length,

five feet, and thickness, two inches; making a mass of two thousand six hundred and forty cubic inches of elastic marble. This slab, when shaken, undulates sensibly backwards and forwards; when supported at the two extremities, the middle forms a curve of about two inches from a horizontal line: and when turned over, recovers itself, and inclines as much the other way. It has many other curious properties.

Natural History of the Pearl.

49. The production of the pearl is one of those mysterious operations of nature which the ingenuity of man has not yet been able to unravel. The Arabs, with whom the pearl was an article of great traffic, entertained a notion (which they had from the Brahmins) that when it rained, the animal rose to the surface to catch the drops which turned into pearl. By some of the natives they are considered to be formed of certain mineral substances carried to the banks by the river which is opposite to them; by others, they are supposed to be formed from dew-drops in connexion with sun-beams which was pretty nearly the opinion entertained by Pliny and the ancient naturalists.

Some have thought them to be an accretion within the body of the animal of the super-abundant matter with coats over the inside of the shell, called mother-of-pearl, and to which it is very common to find little knobs adhering, precisely like pearls, but not of a clear water. Others again, consider them as the effect of disease or injury, like bezoars and other stones found in various animals, pearls being generally composed of lamellæ or coats, formed round a foreign nucleus. In the early ages of the Christian era, the people who lived on the borders of the Red Sea were acquainted with the method of forcing certain shell-fish to produce pearls; as the Chinese at present do the Mytilus Cygneus, the swan muscle, by throwing into the shell, when it opens, five or six minute mother-of-pearl beads strung on a thread. In the course of a year these are found covered with a pearly crust, which perfectly resembles the real pearl. It is supposed that if sharp pointed wires be thrust through the shells of certain species of muscles and oysters, the animal protects itself from being injured and galled, by throwing off a substance which coats them over with little round knobs resembling pearls. Beckman says, that "Linnæus once showed him, among his collection of shells, a small box filled with pearls, and said—*Hos uniones confeci artificio meo; sunt tantum quinque annorum, et tamen tam magni.*" They were deposited, the professor adds, near the *Maja Margaritifera,* from which most of the Swedish pearls are procured.

Natural History of Gems.

50. Gems or precious stones are sometimes found of regular shapes, and with a natural polish; and sometimes of irregular shapes, and with a rough coat. The first sort may be considered as of the the pebble kind, and are said to be found near the beds of rivers, after great rains: the others are found in mines, and in the clefts of rocks.

The gems of the first sort were what the ancients most usually engraved upon: these are commonly called Intaglios; and they are mostly of a long oval figure, inclining to a point at each end, convex as well on the engraved face, as on the others, with a ridge running from end to end on the under side, which is hereby, as it were, divided into two faces; both which are also, though not so distinctly, parted from the upper face, by another ridge running quite round the oval.

The stone most commonly found engraved is the beryl. The next is the emerald; and then the jacinth. The chrysolite is but rarely found engraved; as are also the crystal, or oriental pebble, the garnet, and the amethyst.

Of the beryl there are three species; the red, inclining to orange colour, transparent and lively; the yellow, of an ochre colour, and the white, commonly called the chalcedony, of the colour of sheer milk. These two last have less life than the first.

The emerald is green, nearly of the colour of stagnated water; sometimes tolerably clear, but, for the most part full of black and white specks.

The jacinth is of a deep tawny red, like very old Port wine, but lively and transparent.

The chrysolite is of a light green grass colour, and is supposed to have been the beryl of the ancients, transparent, but not lively.

The crystal or oriental pebble is harder and more lively than the common rock crystal; is of a silvery hue, and but very little inferior to the white sapphire.

The garnet is of the same colour as the jacinth, but more inclining to the purple, and not so lively.

The amethyst is of a deep purple, transparent and lively.

The following is a general table of what are usually called precious stones.

The beryl, red, yellow, or white; emerald green; jacinth, of a deep tawny red; chrysolite, of a light grass-green; crystal, or oriental pebble, of a silvery white; garnet, of a deep red claret colour; amethyst, purple; diamond, white; ruby, red or crimson coloured; emerald, of a deep green; aqua marina, of a bluish sea green, like sea water; topaz, of a ripe citron yellow; sapphire, of a deep sky blue, or of a silver white; cornelian, red or white; opal, white and changeable; vermillion stone, more tawny than the jacinth.

All these stones are more or less transparent: the following are all opaque.

The cat's-eye, brown; red-jasper, called also thick cornelian, of the colour of red ochre; jet, black; agates, of various sorts; blood-stone, green, veined or spotted with red and white; onyx, consisting of different parallel strata, mostly white and black; sardonyx, of several shades of brown and white; agate-onyx, of two or more strata of white, either opaque or transparent; alabaster, different strata of white and yellow, like the agate-onyx, but all opaque; toad's-eye, black; turquoise, of a yellowish blue inclining to green; lapis lazuli, of a fine deep blue.

Of most of the species beforementioned there are some of an inferior class and beauty. These are commonly called by jewellers occidental stones: they are mostly the produce of Europe, and found in mines or stone quarries; and are so named in opposition to those of a higher class, which are always accounted oriental, and supposed to be only produced in the East.

The onyx, sardonyx, agate-onyx, alabaster of two colours or strata, as also certain shells of different coats, were frequently engraved by the ancients in relief: and these sorts of engravings are commonly called cameos. They also sometimes ingrafted a head, or some other figure in relief of gold, upon a blood stone.

Besides which there are some antiques, mostly cornelians, that are covered with a stratum of white. This stratum has by some been looked upon as natural; but it was really a sort of coat of enamel that was laid on.

The stones esteemed the best for engraving upon, were the onyx and sardonix; and next to them, the beryl and the jacinth.

The ancients engraved most of their stones, except the onyx and the sardonyx, just as they were found; their natural polish excelling all that can be done by art; but the beauty of the several species of onyx could only be discovered by cutting.

The merit both of intaglios and cameos depends on their erudition or the goodness of the workmanship, and on the beauty of their polish.

The antique gems of Greek work are the most esteemed; and next to them the Roman ones, in the times of the higher empire.

"Lapidaries employ a considerable quantity of diamond in powder, which they use with steel instruments, to divide pebbles and precious stones. The small pieces of diamond of which the powder is made, are worth twenty-eight shillings a carat. The use of the diamond in this way is very extensive. Had nature withheld the diamond, the pebble, the agate, and a variety of other stones, would have been of little value, as no other substance is hard enough to operate upon them. In this way rock crystal from Brazil is divided into leaves, and ground and polished with diamond dust for spectacles, and other optical instruments."

CHAPTER III.

METEOROLOGY.

SECTION I.

GENERAL PRINCIPLES.

WHATEVER is engendered in the air which surrounds us, and which appears to be beyond the moon, is a meteor. The word signifies a body raised above the earth we inhabit.

51. Meteors are composed of vapours and exhalations. Vapours are particles of water which mingle with the air. Exhalations are particles of all the different terrestrial bodies, which rise into the air, such as sulphur, salts, bitumens, and other bodies of different natures, more or less combustible, solid, or heavy. *Mists* are those collections of vapours, which chiefly rise from fenny moist places, and become more visible as the light of the day decreases. *Clouds* are nothing else but a collection of moist particles, exhaled from the sea and earth by the heat of the sun, suspended aloft in the air and soaring on the wings of the wind.

52. *Evaporation* is that process whereby water is converted into vapour, which, being lighter than the atmosphere, is raised above the surface of the earth, and afterwards by a partial condensation forms clouds. Vapour is an elastic invisible fluid like common air, but lighter; being to common air, of the same elasticity, as 10 to 14, or, 10 to 12.

When water is heated to 212°, it boils, and is converted into steam; and the same change takes place in lower temperatures; but in the latter case the evaporation is slower, and the elasticity of the steam is weaker. A considerable portion of the earth's surface being covered with water, it is constantly evaporating and mixing in the atmosphere in the state of vapour.

More vapour rises during hot weather than during cold; hence the quantity evaporated depends upon temperature. At the temperature of 180°, the quantity evaporated is one half of what is lost at 212°.; at 164°, it was one-third of that at 212°.; at 152°, one-fourth; at 144°, one-fifth; at 138°, one-sixth.

The quantity of vapour which rises from water, under the same temperature, varies according to circumstances. It is least in calm weather, greater during a breeze, and greatest with a strong wind.

The quantity of vapour evaporated at any degree of heat or wind depends on the quantity of vapour already in the atmosphere, as is proved by the following illustration.

Illus. From experiments at Liverpool, it appears that the mean annual evaporation from the surface of water, amounted to 36.78 inches. The proportion for every month was the following:

January ....Inches	1.50	July ...... Inches	5.11
February..........	1.77	August	5.01
March............	2.64	September	3.18
April	3.30	October...........	2.51
May	4.34	November.........	1.51
June	4.41	December.........	1.49

Mr. Dalton found the evaporation from the surface of water in one of the driest and hottest days of summer, rather more than 0.2 of an inch.

The mean annual evaporation over the whole surface of the globe is estimated at thirty-five inches. And thirty-five inches from every square inch on the superficies of the globe make 94.450 cubic miles of water annually evaporated over the whole earth.

Were this prodigious mass of water all to subsist in the atmosphere at once, it would increase its mass by about a twelfth, and raise the barometer nearly three inches. But this never happens; no day passing without rain in some part of the earth, so that part of the evaporating water is constantly precipitated.

CLOUDS.

53. We have defined what clouds are; and therefore in this article we will illustrate the atmospherical phenomena, on which depend the appearance of clouds, the production of rain and springs.

The greater part of the phenomena of the atmosphere arise from the water which, being raised by evaporation, is transported from one place to another in vapour, and which, physically speaking, is a component part of the air. When by any means a portion of this is deprived of its heat, it re-appears in minute drops, which being at first uniformly diffused, lessen the transparency of the air in proportion to their abundance.

Towards evening there is usually a sufficient quantity of diffused water, which becomes visible as *haze*. Whether this is the veil, which, being drawn over the sable of the sky, converts it to a blue of various degrees of intensity; or whether it share with the transparent air in producing this effect is of no moment here.

54. The next stage is *dew*, or haze, for the latter term seems more appropriate than the former to the appearance of dew while it is falling. Here the drops have so far become collected as to form an aggregate sufficiently visible in the air.

To this succeed the aggregate called *clouds*; from which are formed *rain*, *snow*, and *hail*, and by which the product of evaporation is finally restored to the earth.

The excess of the falling water over what is evaporated, passes off by springs and rivers to those reservoirs or oceans which form the far greater part of the surface of the globe. Tracts of mountainous forests invite the rain, and protect the springs, the accumulated heat on plains causes the clouds to pass over them, or to be dissipated.

The atmosphere, at the height where clouds appear, is undisturbed by the obstacles which throw it into streams and eddies near the surface of the earth, and it flows in a more even current. Hence the particles of water it contains assume a certain arrangement; and constitute a form, often equally well defined at a distance with that of solids, although were we to penetrate it, we should perceive only a grey mist, the spirit of air.

RAIN.

55. When the heat or density of the air, or the electricity of the clouds is suddenly disturbed, the particles of vapour rush together, and form drops of water too heavy to continue suspended in the atmosphere. They then fall in the shape of rain, increasing in size as they fall, by combining with the floating vapours as they are precipitated to the earth.

Previous to rain, the clouds in the lowest atmosphere change their appearance, become denser, irregular in shape, and rock-like in superstructure, with fleecy protuberances about their base. While this process is going on, different other forms of clouds, which have previously appeared above, are lost, to all appearance, as if they had suddenly evaporated. The air is now damper, and there is frequently a mistiness above. The surrounding air being damp, the process goes on, affecting clouds more distant, and the result is rain.

If you observe the gathering clouds over head, they are spread like veils of various texture; some are black and heavy, others move under these from the windward, and when the whole have gathered the rain falls copiously. If it be a continued gentle shower, the strata of clouds will spread in a horizontal diffusion, and then separate till the whole are dissolved.

The mean annual quantity of rain is greatest at the equator, and decreases gradually in the following scale, as we approach the poles. Thus, at

Granada, West Indies, is at	126 inches.
Cape François	120
Calcutta	81
Rome	39
England	35
Petersburg	16

The number of rainy days is smallest at the equator, and increases in proportion as we move north or south. From north latitude 12°. to 43°., the mean number of rainy days is seventy-eight; from 43°. to 46°. the mean number is 103; from 46°. to 50°. it is 134; from 51°. to 60°. 161.

The number of rainy days is often greater in winter than in summer; but the quantity of rain is greater in summer than in winter. At Petersburg the number of rainy or snowy days during winter is eighty-four, and the depth of rain which falls is only about five inches; during summer the number of rainy days is nearly the same, but the depth of rain is about eleven inches. More rain falls in mountainous conntries than in plains. Among the Andes it is said to rain almost perpetually; while in Egypt it hardly ever rains at all.

The mean depth of rain falling at 147 places situated between north lat. 11°. and 60°. deduced from tables, is 34.7 inches. If the mean annual depth of rain for the whole globe is thirty-four inches, and the superficies of the globe consist of 170,981,012 square miles, the quantity of rain falling annually will amount to 91,751 cubic miles of water.

The dry land amounts to 52,745,253 square miles; the quantity of rain falling on it annually therefore will amount to 30,960 cubic miles. The quantity of water running annually into the sea is 13,140 cubic miles; a quantity of water equal to this must be supplied by evaporation from the sea, otherwise the land would soon be completely drained of its moisture.

In England it generally rains less in March than in November, in the proportion of seven to twelve; less in April than October, in the proportion of one to two nearly; less in May than September; and the chances that it does so are at leat four to three; but, when it rains plentifully in May, it rains but little in September: and when it rains one inch or less in May, it rains plentifully in September.

OF DEW.

56. Dew is vapour condensed into drops. Under certain circumstances the air holds not the same quantity of water in solution, and the result is a deposition of it in aqueous particles; during day, and under the effects of electricity, definite and floating clouds are the result, and the processes of rain often commence; but in fine weather, in the evening, the vapour plane being destroyed, the vapour so deposited precipitates down in dew.

During the heat of the day a great quantity of vapour is thrown into the atmosphere from the surface of the earth and waters. When the evening returns, if the vapour has not been carried off in part by currents, it will often happen that more remains diffused in the general atmosphere than the temperature of the night will permit to subsist under the full pressure of the aqueous atmosphere. A decomposition of the latter then commences, and is continued until the general temperature and aqueous pressure arrive at an equilibrium, or until the returning sun puts an end to the process.

OF FOGS.

57. Fogs are clouds floating on the surface of the earth, and clouds are fogs in the higher regions of the atmosphere; from many places they may be seen moving in the vallies, and often in the vallies they may be seen creeping along the sides of the mountains.

OF SNOW AND HAIL.

58. *Snow* consists of those vapours which are frozen while the particles are small; for, if these stick together after they are frozen, the mass formed out of them will be of a loose texture, in little flakes or fleeces, of a white substance, somewhat heavier than the air: they therefore descend in a slow and gentle manner in snow. But you will observe that snow is formed by this process of regular crystallization among minute frozen particles of water floating in the air. It is remarkable, that previous to, and during, the fall of snow in quantity, the temperature continues about 32°.

The structure of a flake of snow proves that a drop of rain is also composed of a great number of smaller drops. When these come together in the act of freezing suddenly, they form a nucleus of white spongy ice, which by its extreme coldness, becoming incrusted with clear ice, from the water it collects in its descent, constitutes hail as we usually see. Hail has been likewise observed perfectly transparent, and having the form of an oblate spheriod, shewing that it consisted of drops which had been frozen entire in falling with a rotatory motion.

Hail, which is a more compact mass of frozen water, consists of such vapours as are united into drops, and are frozen while they are falling. They assume various figures, being sometimes round, at other times pyramidal, cuneated, angular, thin, and flat, and sometimes stellated, with six radii like the small crystals of snow; and natural historians furnish us with various accounts of surprising showers of hail, in which the hailstones were of extraordinary magnitude.

OF HALOS, PARHELIA, &c.

59. A *halo* is an extensive luminous ring, including a circular area, in the centre of which the sun or moon appears; whose light, passing through an intervening cloud, gives rise to the phenomenon. Those about the moon are most common.

Of Corona. When the sun or moon is seen through a thin cloud, a portion of the cloud, round the sun or moon, appears lighter than the rest; and this luminous disc is called a *corona*. They are of various sizes, but they seldom exceed 10°. in diameter: they are generally faintly coloured at their edges. Frequently when a halo encircles the moon, a corona surrounds it.

Parhelia or mock suns vary considerably in general appearance: sometimes the sun is encircled by a large halo, in the circumference of which the mock suns usually appear: which have often small halos round them.

The *paraselene*, the *parhelion*, and the several kinds of *halo* and *corona*, all appear to result from the intervention of clouds between the spectator and the sun or moon, through which the light passes.

OF METEORS.

60. The most common sort of igneous meteors, are those very small meteors which are prevalent in clear frosty winter nights, and in summer also, when there are dry easterly winds with a clear sky. They leave little or no train behind them, and shoot along in straight lines, generally oblique downwards.

The falling stars, and other fiery meteors, which are frequently seen at a considerable height in the atmosphere, and which have received different names according to the variety of their figure and size, arise from the fermentation of the effluvia of acid and alkaline bodies, which float in the atmosphere. When the more subtile parts of the effluvia are burnt away, the viscous and earthy parts become too heavy for the air to support, and by their gravity fall to the earth.

The disappearance of fiery meteors is frequently accompanied by a loud explosion like a clap of thunder, and heavy stony bodies have been observed to fall from them to the earth. Dr. Thomson has given a table of thirty-six showers of stones, with the places where they fell, the dates and the testimonies annexed.

These stony bodies when found, are always hot, and their size differs from a few ounces to several tons. They are usually round, and always covered with a black crust. When broken, they appear of an ash-grey colour, and of a granular texture like coarse sand-stone. These substances are probably concretions actually formed in the atmosphere, but in what manner no rational account has yet been given.

61. Of the Ignis Fatuus, commonly called *Will-with-a-Wisp*, or *Jack with a Lantern*. This meteor, like most others, has not failed to attract the attention of philosophical inquirers. Sir Isaac Newton, in his Optical Queries, calls it a vapour shining without heat. Various accounts of it may be seen in the Philosophical Transactions. The most probable opinion is, that it consists of inflammable air, or oleaginous matter, emitted from a putrefaction and decomposition of vegetable substances, in marshy grounds; which being kindled by some electric spark, or other cause unknown to us, will continue to burn or reflect a kind of thin flame in the dark, without any sensible degree of heat, till the matter which composes the vapour is consumed. This meteor never appears on elevated grounds, because they do not sufficiently abound with moisture to produce the inflammable air, which is supposed to issue from bogs and marshy places. It is often observed flying by the sides of hedges, or following the course of rivers: the reason of which is obvious, for the current of air is greater in these places than elsewhere.

These meteors are very common in Italy and in Spain. Dr. Shaw has described a remarkable Ignis Fatuus, which he saw in the Holy Land, when the atmosphere was so uncommonly thick and hazy, that the dew on the horses' bridles was remarkably clammy and unctuous. This meteor was sometimes globular, then in the form of the flame of a candle, presently afterwards it spread itself so much as to involve the whole company in a pale harmless light, and then it would contract itself again, and suddenly disappear; but, in less than a minute, it would become visible as before, and running along from one place to another, with a swift progressive motion, would again expand itself, and cover a considerable space of ground.

62. OF THE AURORA BOREALIS, OF NORTHERN LIGHTS. There have been various opinions and conjectures respecting the cause and properties of these extraordinary phenomena; and the most probable opinion is, that they arise from exhalations, and are produced by a combustion of inflamable air, caused by electricity.

This inflammable air is generated particularly between the tropics, by many natural operations, such as the putrefaction of animal and vegetable substances, volcanoes, &c.; and being lighter than any other, ascends to the upper regions of the atmosphere, and, by the motion of the earth, is urged towards the poles; for it has been proved by experiments that, whatever is lighter, or swims on a fluid which revolves on an axis, is urged towards the extreme points of that axis: hence these inflammable particles continually accumulate at the poles, and by meeting with heterogeneous matter take fire, and cause those luminous apparences frequently seen towards the polar regions.

We have very few accounts of the Aurora Australis, or Southern Lights, owing perhaps to the want of observations in those remote parts of the globe, and a proper channel of information. Captain Cook, in his second voyage towards the south pole, says: " (February 17th, 1773,) We observed a beautiful phenomenon in the heavens, consisting of long columns of clear white light, shooting up from the heavens to the eastward, almost to the zenith, and gradually spreading over the whole southern part of the sky. Though these columns were in most respects similar to the Aurora Borealis, yet they seemed to differ from them in being always of a whitish colour. The stars are sometimes hid by, and sometimes faintly to be seen through the substance of these Auroræ Australes. The sky was generally clear when they appeared, and the air sharp and cold, the thermometer standing at the freezing point; the ship being in latitude 58° south.

In high latitudes the Auroræ Boreales appear with the greatest lustre, and extend over the greater part of the hemisphere, varying their colours from all the tints of yellow to the most obscure russet. In the north-east parts of Siberia, Hudson's Bay, &c. they are attended by a continued hissing and cracking noise through the air, similar to that produced by fire-works.

63. OF THE RAINBOW. The rainbow is the most beautiful meteor with which we are acquaint-

ed; it is never seen but in rainy weather, where the sun illuminates the falling rain, and when the spectator turns his back to the sun. There are frequently two bows seen, the interior and exterior bow. The interior bow is the brightest, being formed by the rays of light falling on the *upper parts* of the drops of rain; for a ray of light entering the upper part of a drop of rain will, by refraction, be thrown upon the inner part of the spherical surface of that drop, whence it will be reflected to the lower part of the drop, where undergoing a second refraction, it will be bent towards the eye of the spectator, hence the rays which fall upon the interior bow come to the eye after two refractions and one reflection, and the colours of this bow from the *upper part* are *red, orange, yellow, green, blue, indigo,* and *violet.* The exterior bow is formed by the rays of light falling on the *lower parts* of the drops of rain; these rays, like the former, undergo two refractions, *viz.* one when they enter the drops, and another when they emerge from the drops to the eye; but they suffer two or more reflections in the interior surface of the drops; hence the colours of these rays are not so strong and well defined as those in the interior bow, and appear in an inverted orer, *viz.* from the *under part* they are *red, orange, yellow, green, blue, indigo,* and *violet.*

To illustrate this by experiment, suspend a glass globe filled with water in the sun-shine, turn your back to the sun, and view the globe at such a distance that the part of it the farthest from the sun may appear of a full red colour, then will the rays which come from the globe to the eye make an angle of 42 degrees with the sun's direct rays; and if the eye remain in the same position, and another person lower the glass globe gradually, the orange, yellow, green, &c. colours, will appear in succession, as in the interior bow. Again, if the glass globe be elevated, so that the side nearest to the sun may appear red, the rays which come from the globe to the eye will make an angle of about 50 degrees; then, if another person gradually raise the glass globe, while the spectator remains in the same position, the rays will successively change from red to orange, green, yellow, &c. as in the exterior bow.

SECTION II.

METEOROLOGICAL PHENOMENA.

Aerial Vortex.

64. A very singular phenomenon took place in Poland on the 10th of May, 1818, which has been termed an *air-spout.* It committed dreadful ravages in the neighbourhood of Prague. Clouds suddenly rose in the east, which rapidly enveloped the whole east and south of the heavens, the west wind became more violent, and rapidly alternated with the east, so that a violent conflict between the two winds was perceived. During this conflict there was formed among the clouds a dark opaque pillar (or air-spout), the diameter of which was about twenty fathoms, and which rose in a whirlwind from the earth to the clouds, which hung very low. It committed dreadful ravages in the fields, carrying with it in its course, or scattering all around, stones, sand, and earth, and continued its progres, with a hollow sound, towards the east. By the refraction and reflection of the sun's rays, falling from the west on the pillar of dust, it looked like a column of fire in the clouds.

This terrible pillar revolved with incredible rapidity, sometimes horiozontally, sometimes vertically, furrowing the ground, which it tore up, with its stones, several pounds in weight, which it hurled, whizzing like sky-rockets, into the air. This lasted about fifteen minutes. A silvery stripe, in the shape of a funnel, the point of which was turned towards the earth, was now formed in the middle of this air-spout, which began at its top, and almost reached the centre. This silvery stripe contracted itself several times, and at last totally disappeared.

Luminous Appearance of the Atmosphere at Maracaybo,

65. The celebrated traveller, M. Humboldt says, that a luminous appearance takes place, every night, in South America, on a mountainous and uninhabited spot on the borders of the river Catatumbo, near its junction with the Sulia.

Being nearly in the meridian of the opening of the Lake of Maracaybo, navigators are guided by it as by a lighthouse. This light is distinguished at a greater distance than forty leagues. Some have ascribed it to the effects of a thunder-storm, or of electrical explosions, which might take place daily in a pass in the mountains; while others pretend that it is an air-volcano. M. Palacios observed it for two years at Merida. Hydrogen gas is disengaged from the ground in the same district: this gas is constantly accumulated in the upper part of the cavern Del Serrito de Monai, where it is generally set on fire to surprise travellers.

Showers of Red Snow and Rain which fell in Italy.

66. A shower of red snow fell in Carniola, in the nights of the 5th and 6th of March, 1803. On the same night, a shower of snow, of a rose colour, fell over the surface of Carnia, Cadore, Belluno, and Feltri, to the height of twenty centimetres. The earth was previously covered with snow of a pure white, and the coloured snow was succeeded by other of a pure white; neither were the two kinds mingled together. But remained perfectly distinct even during liquefaction. When a portion of this snow was melted, and the water evaporated, a little finely-divided earth, of a rosy colour,remained, not attractable by the magnet, and consisting of silex, alumine, and oxyde of iron.

The same phenomenon happened at the same time in the mountains of Valtelline, Bresci, and the Tyrol. This snow was of a red or blood-rose colour, and was underlaid and covered with white snow. Its colour faded gradually until it was dissolved. On the same evenings of the 5th and 6th of March, 1803, a shower of red snow fell at Pezzo, at the extremity of the Valle Camonica. It was preceded by a very violent wind on the 5th.

On the evening of the 14th and 15th of March, 1813, coloured rain and snow fell over a very large extent of country. Red rain fell in the two Calabrias, and on the opposite part of Abruzzo, the wind being at east and south-east. Snow and hail of a yellow red colour, fell over all Tuscany with a North wind. Red snow fell at Tolmezzo, the wind being at north-east, and in the Carnia Alps; and, finally, snow of a brownish yellow colour fell at Bologna, the wind being south-west.

A pound of this last snow was found to contain three grains of earthy powder. During the evaporation, a black substance was deposited, and the water became dirty yellow. The taste of this earthy substance was at first styptic, and then bitter. It deflagrated with nitre, and, on being analyzed, gave the following results: 300 gr. were composed of

Combustible, vegetable, or animal matter......	96
Red oxyde of iron	96
Alumine	36
Silex	69
	297

67. On the 15th of April, 1816, coloured snow again fell in Italy, on Tonal and other mountains; it was of a brick colour, and left an earthy powder, very light and impalpable, unctuous to the touch of an argillaceous odour, and tasting a little acid, saline, and astringent. These characters agreed with those of the powder left by the coloured snow of March, 1803.

This powder analyzed gave the following results:

Silex	8 gr.
Iron	5
Alumine	3
Lime	1
Carbonic acid..	.5
Sulphur.	.25
Empyreumatic oil........................	2
Carbon	2
Water (by re-agents)	2
Loss	2.25
	26

The extent of country covered by these showers, as in 1803 and 1813, extending to eight degrees in length and breadth, proves that the cause is not local, but very general. These phenomena happen precisely at the time of the spring equinoxes, when impetuous winds are flying about, which originate in very distant countries. These winds it is supposed, may possibly elevate the sand, of distant regions in the air, and may convey the more minute particles to immense distances; and these, adhering to the water of the clouds, at last descend with it, either as hail, snow, or rain, and produce the phenomena under consideration.

Meteoric Stone which fell near Chantonnay, in France.

68. On the 5th of August, 1812, at two o'clock in the morning, whilst the weather was calm and the sky clear, a meteor, dazzling with light, struck the sight of some travellers and countrymen in the neighbourhood of Chantonnay, in the department of La Vendée, on the road from Nantes to La Rochelle. It was said to have been seen at many leagues distance. The time of its duration was not observed, but it terminated in a violent explosion, which was compared to the loudest clap of thunder which had been heard in that country.

In the middle of the day the master of the farm of la Haute Revétison, near Chantonnay, perceived, in a field near to his house, a large stone, which he had never before observed. It was buried two feet and a half in the earth, and had a strong smell of sulphur, which it retained during six months, but which at last was lost. Having undergone a chemical examination by M. Dubisson, that gentleman gave the following account of its composition.

1. The crust, or envelope, appears to me to differ from that of other falling stones of this kind, in passing from a black colour to the yellow of peroxyde of iron. 2. It differs also from other pieces of this kind in the internal parts, giving sparks when struck by steel, though not so abundantly as the outside. 3. The internal part, like the crust,

scratches glass. 4. The form of the mass appears to have been rounded, and to have had many cells and cavities. The interior is granular, of an earthy appearance, with the exception of some brilliant points of meteoric iron, which are abundant, and some of the sulphuret of iron, rather rare. Its colour is variable, it passes from the common grey to the yellow of oxyde of iron, and afterwards to a blackish brown.

Account of an Aërolite which fell at Chassigny, a village in France.

69. On the 3d of October, 1815, in the commune of Chassigny, a village four leagues to the south-east of Langres, at half past eight in the morning, the sky being clear and serene, and a gentle east wind prevailing, a rumbling noise was heard, like the discharge of musquetry and artillery. This noise, which seemed to come from the north-east, and from a cloud which hung over the horizon, of an indeterminate form, and a grey colour, had lasted a few minutes, when a man at work in a vineyard at some distance from the village, and who had his eyes fixed on this cloud, hearing a whistling like that of a cannon ball, saw an opaque body fall a few paces from him, and which emitted a dense smoke. Running to the spot, he saw a deep hole in the ground, and around it were fragments of stone of a peculiar kind, which he found as hot as if they had been long exposed to a strong sun. Some persons in the village of Chassigny, and parts adjacent, who happened to be sitting on the ground, thought they felt the shock of an earthquake during the detonation; but the peasant who saw the stone fall experienced no such sensation.

Account of the above Aërolite, by M. Vauquelin.

1. Colour: brown externally, pearl grey internally.
2. Contexture: grainy, and broken in every direction.
3. Solidity: very slight, crumbling with the greatest facility.
4. Aspect: shining, and as if varnished.
5. Sound: none. Although it appears to have been roasted, it has not the dryness nor the hardness of glass when it is

broken; it seems, on the contrary, to be soft under the pestle, which soon pounds it.

6. It has no action on the magnetic needle, and yet the crust with which it is covered has a slight effect; this announces that it contains iron in the state of oxyde.

7. It forms a jelly with the acids. Hence it must be concluded that the silex is therein combined with some principle.

Ten grammes contained as follows:—

Silex	3.39 gr.
Oxydated iron	3.10
Magnesia	3.20
Metallic chrome	.20
	9.89

It contained, therefore, neither sulphur nor nickel, and the iron in it is entirely oxydated; whereas, all other aërolites contain those two substances, and the iron has always been in the metallic state, at least for the most part. A part of the silex contained in the stone is only in the state of mixture in the sandy form: and another more abundant portion than the first is entirely combined with the magnesia, and probably with the iron, since it is dissolved at the same time with those two bodies in the sulphuric acid. There is, in the present stone, twice as much magnesia as in those which have been hitherto analysed; perhaps its softness was owing to this cause. And lastly, the chrome is found in it in the metallic state, which announces that it must have resisted the oxydating action which burnt the iron. The quantity of this metal is also more considerable than usual.

Asiatic Aërolite.

70. In 1819 a meteoric stone fell near the village of Dooralla, in India, and spread universal consternation over a country, where the people look on the Phenomena of Nature as presages of some awful calamity. The day was clear and serene, not a cloud to be seen, and the thermometer in the shade stood at 68°. Some people at work in a field, hearing suddenly a report in the sky, louder than that of a cannon, and then a sudden rushing noise, looked towards the quarter from whence it proceeded, and discovered a large black body in the air moving apparently towards them, but passing with incon-

ceivable velocity, buried itself in the earth, about sixty paces from where they stood.

The Bramins made much ado about this phenomenon, which, when dug out and examined by some British officers, proved to be an ill shapen triangular stone rather more than 25lbs. in weight, and covered with a pellicle thinner than a wafer, of a black sulphureous crust. Either in its fall or in digging it up, the aërolite received a fracture, whence the interior presents to the view iron pyrites and nickel; but it emits no smell of sulphur.

CHAPTER IV.

GEOGRAPHICAL SCIENCE.

SECTION I.

INTRODUCTION.

71. GEOGRAPHY is the science which treats of the earth; for the term is derived from γη *earth* and γραφω *I write.*

In describing, therefore, the terrestrial globe, it is obvious that geography may be divided into as many distinct, yet important branches, as there are parts constituting the homogeneous body which we call the earth.

Part of these would belong to astronomical calculations or observations; and would have reference to the various circles with which the earth is supposed to be invested:—Part would be assigned to the natural divisions and products of the earth:—Part to a comparative view of the kingdoms and states in ancient and modern times; and Part to those phenomena that present themselves to the inhabitants of the earth.

In this light the first branch may be called Astronomical Geography; the second, Pure and Natural Geography; the third, Political Geography; the fourth, Physical Geography. But for brevity's sake we will divide it into two parts, Pure and Mixed Geography. The former shall embrace the three first branches: the latter, the fourth branch of the subject.

SECTION II.

ASTRONOMICAL GEOGRAPHY.

72. THE *axis* of the earth is an imaginary line passing through its centre, upon which it is supposed to turn, and about which all the heavenly bodies *appear* to have a diurnal revolution.

The *poles* of the earth are the extremities of this axis. The celestial poles are two imaginary points in the heavens, exactly above the terrestrial poles. The one is the north, and the other the south pole.

The circles supposed to be drawn about the earth, are divided into two classes; viz. great and small circles.

The great circles are these: the *equator*, which passes round the centre of the earth perpendicular to its axis, and at an equal distance from either pole. The *equator* divides the earth into two equal hemispheres.

The *ecliptic*, in which the sun makes his apparent annual progress among the fixed stars, is another great circle inclined to the plane of the equator in an angle of 23° 28′ nearly.

The other great circles of the sphere are called *meridians*, which completely envelope the globe, intersecting the equator at right angles. These meridians are called lines of longitude.

The *zodiac* is a space which extends about 8° on each side of the ecliptic, like a belt or girdle, within which the motions of all the planets are performed.

Signs of the zodiac. The ecliptic and zodiac are divided into twelve equal parts, called signs, each containing 30°; and the sun makes his apparent annual progress through the Ecliptic at the rate of nearly a degree in a day.

The names of the signs, and the days on which the sun enters them are as follow:

Spring signs.	*Summer signs.*
♈ *Aries*, the Ram, 21st of March.	♋ *Cancer*, the Crab, 21st of June.
♉ *Taurus*, the Bull, 19th of April.	♌ *Leo*, the Lion, 22nd of July.
♊ *Gemini*, the Twins, 20th of May.	♍ *Virgo*, the Virgin, 22nd of August.

All *northward* of the Equator.

Autumnal signs.	*Winter signs.*
♎ *Libra*, the Balance, 23d of September.	♑ Capricornus, the Goat, 21st of December.
♏ *Scorpio*, the Scorpion, 23d of October.	♒ *Aquarius*, the Water-bearer, 20th of January.
♐ *Sagittarius*, the Archer, 22d of November.	♓ *Pisces*, the Fishes, 19th of February.

These are called southern signs, being all *south* of the equator.

The *equator* is a great circle, and when referred to the heavens, is called the equinoctial: it is sometimes called the Line, or equinoctial line.

The equinoctial line on the earth passes through the middle of Africa, traverses the Indian Ocean, passes through the Isles of Sumatra and Borneo, and the immense expanse of the Pacific Ocean; then extends over the province of Quito, in South America, to the mouth of the River Amazons.

Meridians are lines that are drawn from one pole to the other, directly across the equator.

Meridians are great circles perpendicular to the equator, and passing through the poles.

They are called meridians, because when any of them are, by the motion of the earth, brought directly opposite to the sun, it is always mid-day or noon there.

The meridians may be considered as indefinite in number; and all places lying directly north or south of each other are upon the same meridian. Sometimes by the meridian of a place is understood the half of a great circle passing through that place; the other half is called the opposite meridian.

The brass circle in which the globe hangs, and which is called the *brazen meridian*, may be made to represent the meridian of any place. It is divided into 4 quadrants, of 90 degrees each. On one semicircle the degrees are numbered from the equator towards the poles; on the other, from the poles towards the equator. The former is used in finding the latitude of places, the latter in elevating the globe.

On globes and maps of the world, meridians are drawn through every 10 or 15 degrees. On particular maps, they are sometimes drawn through every degree. They are always drawn from the top to the bottom of maps.

Latitude is the distance of any place, north or south, from the equator.

The latitude of a place is an arc of the meridian intercepted between the equator and the place, and is called north or south, according as the situation of the place is in the northern or southern hemisphere: it can never exceed 90 degrees, that being the distance of the poles from the equator. The latitude is reckoned by degrees and minutes on the brass meridian; in maps it is reckoned at the sides.

Latitude is the same all over the earth, being constantly reckoned from the equator to the poles.

The *longitude* of a place is the distance of the meridian of that place, east or west, from the first meridian.

The longitude of a place is an arc of the equator contained between the first meridian and that of the place. On globes or maps of the world, it is reckoned on the equator; but in particular maps, it is reckoned at the top or bottom.

Geographers in different countries have fixed upon different places for the *first meridian*. The latest geographers, particularly the Dutch, have pitched upon the Peak of Teneriffe; others on the Isle of Palm, one of the Canaries: and, lastly, the French, by order of the King, on the Island of Ferro, another of the Canaries. In Great-Britain the longitude is generally reckoned from the meridian of Greenwich.

The greatest longitude any place can have is 180 degrees, or half the circumference of the globe.

Parallels of latitude are less circles drawn parallel to the equator.

Parallels of latitude become smaller the further they are distant from the equator.

On globes and maps of the world they are drawn through every 10 degrees. In all maps they are the lines drawn from one side to the other.

All places that lie directly east or west from each other are said to lie in the same parallel of latitude.

The *difference of latidude* between two places is the shortest distance between the parallels of those places.

The difference of latitude between two places is an arc of the meridian, included between their respective parallels of latitude.

The *difference of longitude* between two places is the distance between the meridians of these places, counted upon the equator.

The difference of longitude between any two places is an arc of the equator intercepted between their respective meredians.

The *sensible horizon* is an imaginary circle which appears to touch the surface of the earth, and to separate the visible part of the heavens from the invisible, and extends only a few miles.

The *rational horizon* is a great circle parallel to the former, the plane of which passes through the centre of the earth, and cuts the heavens into two equal hemispheres.

The *poles* of the horizon are two points, the one of which, over the head of the spectator, is called the *zenith*; the other which is under his feet, is called the *nadir*.

The *cardinal points* of the horizon are, *north*, *east*, *south*, and *west*.

The *altitude* of any heavenly body above the horizon, is the part of a vertical circle intercepted between the body and the horizon, or it is the angle at the centre of the earth measured by that arc.

The *latitude* of a place upon the surface of the earth, is its distance from the equator; and is either northern or southern, measured in degrees.

The *declination* of a heavenly body, is its distance from the equator, and is either northern or southern.

The *right ascension* of any heavenly body, is its distance from the first point of *aries*, counted on the *equator*.

The two points in which the ecliptic cuts the equator, are called *equinoctial points:* the *vernal* equinox is at the first degree of *aries;* and the *autumnal*, at the first degree of *libra*.

The points of the ecliptic, which are at the greatest distance from the equator, are called the *solstices;* and the circles which pass through these points parallel to the equator are called the *tropics of cancer and capricorn*.

The celestial sphere is said to be *right*, *oblique*, or *parallel*, as the equator is at right angles, oblique, or parallel, to the horizon.

The two tropics and the two polar circles upon the surface of the earth, divide it into five parts, called *zones; viz.* the *torrid* zone, two *temperate*, and two *frigid* zones. The torrid zone lies between the two tropics; the temperate zones between the tropics and polar circles; and the frigid zones between the polar circles and the poles.

The *culminating point* of a star or planet is, that point of its orbit which, on any given day, is the most elevated. Hence a star or planet is said to culminate, when it comes to the meridian of any place: for then its altitude at that place is the greatest.

Apparent noon, is the time when the sun comes to the meridian; *viz.* twelve o'clock, as shewn by a correct sun-dial.

True or *mean noon*, is twelve o'clock, as shewn by a well regulated clock, adjusted to go twenty-four hours in a *mean solar day*.

The *equation of time* at noon, is the interval between the true and apparent noon; that is to say, it is the difference of time shewn by a well regulated clock, and a correct sun-dial.

The *astronomical day* is reckoned from noon to noon, and consists of twenty-four hours; this is called also a *natural* day, because it is of the same length in all latitudes.

The *artificial day*, is the time elapsed between the sun's rising and setting, and is variable according to the different latitudes of places, and the different seasons of the year.

A planet's place as seen from the sun is called its *heliocentric* place, and as seen from the earth, its *geocentric* place.

Two planets are said to be in *conjunction* with each other, when they have the same longitude, or are in the same degree of the ecliptic, though their latitude be different. They are said to be in *opposition* when their longitudes differ half a circle, or when they are on opposite sides of the heavens.

SECTION III.

NATURAL GEOGRAPHY.

73. THE EARTH, upon which we live, was long considered as one large extensive plane. The heavens above it, in which the sun, moon, and stars, appeared to move daily from east to west, were conceived to be at no great distance from it, and to be only designed for the use or ornament of our earth. Mankind, however, are now convinced that they live on a round ball; and the spherical figure of the earth may be proved by a variety of arguments.

Arg. 1. When we are on board a ship at sea, we may be out of sight of land, when the land is near enough to be visible, if it were not hid from our eye by the convexity of the water. In this case the tops of hills, cliffs, steeples, towers, &c. first appear to our view, next the buildings, and last of all the shore; which can proceed from no other cause than the roundness of the earth, whereby the lower objects are longer hid from the sight, than those which are higher.

2. When we stand upon the shore, the highest part of a ship is visible at the greatest distance. If a ship be going from us out to sea, we shall continue to see the mast, after the hull, or body of the ship disappears, and the top of the mast will be seen longest. But if the surface of the sea were quite flat, every part of an object would be equally visible; and not the highest, but the largest part of an object would be visible at the greatest distance, so that we should be able to see the hull of a ship farther off than the mast. But this is contrary to experience; consequently the earth is globular.

3. Several navigators have sailed quite round the earth; not in an exact circle, the winding of the shores preventing them from sailing in a direct course; but by sailing continually to the westward, they have reached the place from whence they at first departed. This was performed by Magellan, Cavendish, Sir Francis Drake, Lord Anson, Bougainville, Commodore Byron, the Captains Carteret, Wallis, Cook, and others.

4. Eclipses of the moon, which are occasioned by the shadow of the earth falling on that planet, demonstrate that the earth is of a globular figure; for this shadow is always circular, whatever situation the earth may be in at that time. Now a body must be globular, which always casts a circular shadow in every position.

5. Nor are the little unevennesses on the earth's surface, arising from hills and vallies, any material objection to its being considered as a round body; because the highest mountains bear less proportion to the bulk of the earth, than the little risings on the coat of an orange bear to that fruit; or a grain of sand to an artificial globe, of nine inches diameter. And accordingly, we find that the mountains and vallies on the surface of the earth cause no irregularities in the shadow, during a lunar eclipse; the circumference thereof being even and regular, and appearing as if cast by a body truly globular.

Of the Magnitude of the Earth.

74. The length of a degree is 367,196 English feet, or 69½ English miles; hence, supposing the earth a sphere, its circumference will be 25,020 English miles, and its diameter 7964 miles.

The Motion of the Earth.

75. The roundness of the earth being thoroughly established, a way is naturally opened for the discovery of its motion. For while it was considered as a plane, mankind had an obscure notion of its being supported, like a scaffolding, on pillars, though they could not tell what supported these. But the figure of a globe is much better adapted to motion.

Obs. 1. This is confirmed by considering, that, if the earth does not move round the sun, not only the sun, but all the stars and planets, must move round the earth. Philosophers, by reckonings founded on the surest observations, have been able to guess pretty nearly at the distances and magnitudes of the heavenly bodies from the earth, and from each other, just as every body, who knows the first elements of mathematics, can measure the height of a steeple, or any object placed on it.

2. It appears, therefore, that if we conceive the heavenly bodies to move round the earth, we must suppose them endowed with a motion or velocity so immense as to exceed all conception. All the appearances in nature, however, may be as well explained by imagining the earth to move round the sun in the space of a year, and to turn on its own axis once in twenty-four hours.

The revolution of the earth round its axis, every twenty-four hours, or its *diurnal* motion, alternately causes day and night, as either side is turned towards or from the sun; and its periodical revolution round that luminary, in three hundred and sixty-five days six hours, or its *annual* motion, produces the four seasons of the year.

To form a conception of these two motions of the earth, we may imagine a ball moving upon a billiard-table, or bowling-green. The ball proceeds forward upon the green or table, not by sliding along like a plane upon wood, or a slate upon ice, but by turning round its own axis, which is an imaginary line drawn through the centre or middle of the ball, and ending on its surface in two points called its poles.

Conceiving the matter then in this way, and that the earth, in the space of twenty-four hours, moves from west to east, the inhabitants on the surface of it, like men on the deck of a ship, who are insensible of their own motion, and think that the shores move from them in a contrary direction, will conceive that the sun and stars move from east to west, in the same time of twenty-four hours, in which they, along with the earth, move from west to east.

Natural Divisions of the Earth.

76. The ancients considered the globe under the three grand divisions of Asia, Europe, and Africa. Here the distinctions were arbitrary, as they often included Egypt under Asia, and they had not discovered

the limits of Europe towards the north-east. Modern discoveries have added a fourth division, that of America, which exceeding even Asia in size, might have been admitted under two grand and distinct denominations, limited by the isthmus of Darien.

It has always been supposed that a vast continent existed in the south of the globe. The second navigation of captain Cooke dispelled for a time the idea. But it is now discovered that a continent exists there. The vast extent of New Holland rewarded the views of enterprize; this, which seems too large to be classed among islands, has been ranked as a fifth division of the globe by various geographers of the present day, and distinguished by the name of *Australasia* which term, however, includes also the encircling islands.

Of the grand divisions of the earth, Asia has ever been esteemed the most populous; and is supposed to contain five hundred millions of souls, if China, as has been averred by the latest writers, comprises three hundred and thirty millions. The population of Africa may be estimated at thirty millions, of America at twenty millions, and one hundred and fifty millions may perhaps be assigned to Europe.

Modern discoveries have evinced that more than two-thirds of the globe is covered with water, which is contained in hollow spaces, or concavites, more or less large. But the chief convexites or protuberances of the globe consist of elevated uplands, sometimes crowned by mountains, sometimes rather level, as the extensive protuberance of Asia. In either case, long chains of mountains commonly proceed from those chief convexites in various directions, and the principal rivers usually spring from the most elevated grounds.

The grandest concavity of this globe is filled by the Pacific Ocean; occupying nearly half its surface from the eastern shores of New Holland, to the western coast of America, and diversified with several groups of islands, which seem in a manner the summits of vast mountains emerging from the waves. This ocean receives but few rivers, the chief being the Amur from Tartary, the Hoan Ho and Kian Ku from China, while the principal rivers of America run towards the east.

Next to this in magnitude is the Atlantic, between the Old and New Continents; and the third is the Indian Ocean. The seas between the arctic and antarctic circles and the poles, have been sometimes styled the Arctic and Antarctic Oceans; but the latter is only a continuation of the Pacific, Atlantic, and Indian Oceans; while the Arctic Sea is partly embraced by continents, and receives many important rivers. Besides these, there are other seas more minute, as the Mediterranean, the Baltic, and others still smaller, till we come by due gradation to inland lakes of fresh water.

The courses of rivers are sometimes marked by oblong concavities, which generally at first intersect the higher grounds, till the declivity becomes more gentle on their approach to their inferior receptacles. But even large rivers are found sometimes to spring from lowland marshes, and wind through vast plains, unaccompanied by any concavity, except that of their immediate course; while on the other hand, extensive vales, and low hollow spaces, frequently occur destitute of any stream. Rivers will also sometimes force a passage where nature has erected mountains and rocks against it, and where the concavity would appear to be in another direction, which the river might have gained with more ease. In like manner, though the chief mountains of Europe extend in a south-easterly and north-westerly direction, yet there are so many exceptions, and such numerous and important variations in other parts of the globe, as to render any attempt at a general theory vain.

From the vast expanse of oceanic waters, arises in the ancient hemisphere, that wide continent, which contains Asia, Europe, and Africa; and in the modern hemisphere, the continent of America, which forms a kind of separate island, divided by a strait of the sea from the ancient continent. In the latter many discoveries of great importance to geography, are of very recent date, and it is not above eighty years since we obtained an imperfect idea of the extent of Siberia and the Russian empire, nor above thirty-five since ample, real, and accurate knowledge of these wide regions began to be diffused. So that, in truth, America may be said to have been discovered by Europeans before many parts of Asia; and of Africa our knowledge continues imperfect, while the latest observations, instead of diminishing, rather increase our idea of its extent, at least in regard to its insular appendages.

But the grandest division of the ancient continent is Asia, the parent of nations, and of civilization: on the north-east and south, surrounded by the ocean; but on the west, divided by an ideal line from Africa; and from Europe by boundaries not very strongly impressed by the hand of nature. The Russian and the Turkish empires, extending over large portions of both continents, intimately connect Asia with Europe. But for the sake of clearness and precision, geographers retain the strict division of the ancient continent into three parts, which, if not strictly natural, is ethical, as the manners of the Asiatic subjects of Russia, and even of Turkey, differ considerably from those of the European inhabitants of those empires.

SECTION IV.

PHYSICAL GEOGRAPHY.

Of the External Appearance of the Earth.

77. To account for the external appearance of the earth, Bishop BURNET in his "Sacred Theory of the Earth," begins with the separation of elements from a fluid mass;—the heaviest particles are supposed to have sank and formed a *nucleus;* the water and air took their respective stations; and upon the water the air afterwards deposited in a rich unctuous shell or crust that contained in itself the elements of vegetation, and clothed the whole with a beautiful verdure. Mountains, seas, protuberances, or inequalities were then unknown; the

equator was coincident with the plane of the ecliptic, and all the charms of spring were perpetual.

Many centuries, however, did not glide away before the sun tore the aforesaid crust, or exterior, into large cracks and fissures, which gradually increased till they extended themselves to the great aqueous abyss. The consequences may be easily anticipated. The waters finding vents thus made, rose higher and higher; the shell was utterly broken up, and destroyed, and that universal deluge took place, of which we have an awful description in Gen. vi. and vii. From this flood, the state of the world is divided into *Diluvian* and Antediluvian.

By this catastrophe, the globe of the earth was not only shook and broke in a thousand places, but the violence of the shock it then underwent, shifted its situation; so that the earth which before was placed directly under the zodiac, became thenceforth oblique to the same; whence arose the difference of seasons, which the antediluvian earth was not exposed to. But at length dry land began to appear, owing to a gradual subsidence of the waters, which retired into caverns and crevices originally existing in the nucleus, or formed by the disruption of the crust. Upon the increasing dry land, vegetation began again to exist; and our present islands and continents were formed, while the sea still occupies in parts its original bed.

Such is a brief outline of Burnet's romance.

78. LEIBNITZ about this time published his "PROTOGŒA," in which he supposes the earth to have been in a state of combustion for many ages, and at length to have gone out for want of fuel. A glassy crust was thus formed, which gave rise to sand and gravel; other kinds of earth resulted from sand and salt; and as the globe cooled, the water which had before been kept in the state of steam assumed fluidity, and falling to the earth, produced the ocean.

79. Whiston's "New Theory of the Earth" leaves us bewildered and perplexed, and is principally deserving notice as accounting for the deluge by the approach of a comet towards the earth.

This comet coming below the moon, would raise a prodigious and strong tide in the small seas, which, on his hypothesis, were in the antediluvian globe of the world; and also in the abyss, which was under the upper crust of the earth. This tide would rise during the approach of the comet, and would be greatest when the comet was at its least distance from the earth. By the force of the tide, and the attraction of the comet, the abyss put on an elliptic figure; the outward crust of the earth, incumbent on the abyss, accommodating itself to that figure, which it would not do while it held solid and conjoined, at last broke, and hence the words of Moses, *the fountains of the great deep being broke up*. The same comet, in its descent towards the sun, passed so close by the body of the earth, as to involve her in its atmosphere and tail for a considerable time; and, of consequence, left a vast quantity of its vapours both expanded and condensed on her surface; but a great part of these being afterwards rarified by the solar heat, would be drawn up again into the atmosphere, but afterwards returning in violent rains, make good what Moses intimates by *the windows of heaven being opened*, and particularly by *the forty days rain*; for, as to the following rain, which with this, made the whole time of raining 150 days, Whiston attributes it to the unlucky earth coming a second time within the atmosphere of the persecuting comet, on its return *from* the sun. Lastly, to remove the waters, he supposes a mighty wind to have arisen, which dried up some, and forced the rest into the abyss again, through the clefts by which they had come up; only a good quantity remained in the *alveus* of the great ocean, now first made, and in the smaller seas, lakes, &c. Whiston only proposed this theory hypothetically at first; that is to say, he only supposed such a comet, because it would feasibly and philosophically account for the phenomenon of the deluge; but upon reconsideration, he thinks there actually was such a comet near the earth at that time; and that the great comet of 1688 is the same.

80. But no one has proceeded to the forming a theory of the earth, with the pomp and circumstance of *Buffon*. And it merits attention from the eloquence with which it is adorned, the extent of information it displays, and the popularity it derived from these sources.

Buffon supposes the planets in general to have been struck off from the sun by a comet; that they consisted of fluid matter, and thence assumed a spherical form: and that by the union of centrifugal and centripetal forces, they are restrained in their present orbits. The earth gradually cooled, and the circumambient vapours condensed upon its surface, while sulphureous, saline, and other matters penetrated its cracks and fissures, and formed veins of metallic and mineral products. The scorified, or pumice-like surface of the earth, acted upon by water, produced clay, mud, and loose soils, and the atmosphere was constituted of subtle effluvia, floating above all the ponderous materials. Then the sun, the winds, the tides, the motion of the earth, and other causes, became effective in producing new changes. The waters being greatly elevated in the equatorial regions, and mud, gravel, and fragments being transported thither from the poles, the highest mountains were formed between the tropics, the lowest towards the poles: and the tropical seas were studded with an infinity of islands. The surface of the earth, once even and regular, became now rough, and irregular: excavations were formed in one part, and land was elevated in another; and during a period of ages, the fragments of the original materials, the shells of various fish, and different other exuviæ, were ground up by the ocean, and produced calcareous strata, and other lowland depositions; these relics of marine animals which we find at such heights above the present level of the sea, render it more than probable that the ocean once entirely overwhelmed the earth. From these phenomena Buffon draws a series of curious and minute conclusions, which our limits forbear us even to particularize: but every one who now contemplates the earth's surface, traces upon it marks of the direst, and most unsparing revolutions, which, from the present order of things, it appears impossible should re-occur, except by the united and continuous agency of the most active powers of destruction. Buffon says this arose from the soft state of the former crust of the earth, and those causes, now imbecile, and slow in their operation, were then more effectually exerted, and results were obtained in a few years, for which ages would now be insufficient. In contemplating the production of rivers, he regards them as having cut their own way to the sea, and in their course gradually wearing down the mountainous lands, filling up vallies, and choaking their exits into the ocean by finely divided materials: thus every thing is slowly returning to its former state; all mountains shall be levelled, every valley raised up, excavations filled up, and the ocean will again cover the earth. We shall not enter into the various confutations which these speculative notions have met with, nor dwell upon many modern theories to which they have given rise; for though the authors of these theories have sometimes clothed their fictions in new dresses, we have no sooner removed the mask, than Burnet or Buffon is instantly recognized.

81. The prevailing theories of the present day are the inventions of Professor WERNER of *Freyburgh*, and DR. JAMES HUTTON, of *Edinburgh*; each of these has been ably supported and elucidated by the proofs, illustrations, and comparative views of acute and eloquent controversialists, and two sects have been formed under the appellation of Wernerians and Huttonians.

The first principle which the Wernerian theory assumes is, that our globe was once covered with a sort of chaotic compost, holding, either in solution or suspension, the various rocks and strata which now present themselves to us as its exterior crust. From some unexplained cause, this fluid began first to deposit those bodies which it held in chemical solution, and thus a variety of chrystallized rocks were formed. In these we find no vegetable or animal remains, nor even any rounded pebbles; but in the strata, which lie upon the crystalline, or first deposits, shells and fragments occasionally occur: these therefore have been termed *transition strata*; and it is imagined that the peopling of the world commenced about this period. The waters upon the earth began now more rapidly to subside, and finely divided particles, chiefly resulting from disintegration of the first formations, were its chief contents:—these were deposited upon the transition rocks, chiefly in horizontal layers. They abound in organic remains, and are termed by Werner, *Floetz* or *secondary rocks*.

It is now conceived, that the exposure of the *primitive transition*, and *secondary* rocks to the agencies of the wind and weather, and to the turbulent state of the remaining ocean, produced inequalities of surface, and that the water retreated into low lands and vallies, where a further deposition took place, constituting clay, gravel, and other *alluvial* formation.

There are also certain substances which instead of being found in regularly alternating layers over the earth, are met with in patches; as rock-salt, coal, basalt, and some other bodies which Werner hath called *subordinate* formations. Lastly, subterraneous fires have sometimes given birth to peculiar and very limited products; and these are called *volcanic* rocks. Such is Werner's account of the production of rocks, which he arranges under the terms *primary transition, secondary, alluvial, subordinate,* and *volcanic formations.*

82. *Hutton*, looking upon the face of nature, gives a very different account of the present order of things, and observes every thing in a state of decay; but as

she has obviously provided for the regeneration of animal and vegetable tribes, the philosopher descries in this apparent destruction of the surface of the earth, the real source of its renovation.

The stupendous mountains exposed to the action of the varying temperature of the atmosphere, and the waters of the clouds, are, by slow degrees, suffering constant diminution; their fragments are dislodged, masses are rolled into the valley, or carried by the rushing torrent into rivers; whence they are transported to the sea. The lower and softer rocks are undergoing similar, but more rapid destruction. The result of all this must be, the accumulation of new matter in the ocean, which will be deposited in horizontal layers. *Hutton* perceives the transition rocks of *Werner*, though not strictly crystalline, made up apparently of finely divided matter, more or less indurated; sometimes very hard in texture, and of a vitreous fracture; that this hardening is most perceptible when in contact with the primitive or inferior rock, which often pervades the transition rocks in veins, or appears to have broken up or luxated the superincumbent masses. The transition or secondary rocks of *Werner* were, according to *Hutton*, deposited at the bottom of the ocean, in consequence of operations similar to those which are now active, and the primary rocks were formed beneath them by the operation of subterraneous fires; their crystalline texture, their hardness, their shape and fracture, and the alterations they have produced upon their neighbours, are the proofs of the correctness of these views. It is by the action of fire then, that rocks have been elevated, that strata have been hardened, and that those changes have resulted, which an examination of the earth's surface unfolds. The production of soils, and of alluvial lands, is considered as dependent upon causes the same as those referred to in the other theory. *Hutton* refers to fire as well as water, for the production of our present rocks: the former consolidating, hardening, and elevating; the latter, collecting and depositing the strata.

Of the Seasons and Climates.

83. The axis of the Earth makes an angle of 23° 28′ with a perpendicular to the plane of its orbit; and keeps *always* the same oblique direction throughout its annual course; hence it follows, that during one part of its course, the north pole is turned towards the Sun, and, during another part of its course, the

south pole is turned towards it in the same proportion; which is the cause of the different seasons, as Spring, Summer, Autumn, and Winter.

84. The seasons in the torrid zone being very different from what we observe in the temperate zone, a short account of them will be necessary.

As it is summer with us when the sun is nearest our zenith, it has by some been imagined, that the inhabitants of the torrid zone have double seasons; namely, two summers, because the sun is twice vertical to them,—two autumns, when he is retiring, &c. But in many places a torrent of rain follows the course of the sun, and the worst season is when the sun is vertical: the only distinction of seasons within the tropics, therefore, is from hot and dry, to hot and rainy; most countries in the torrid zone having six months inclining to a wet, and six months inclining to a dry air.

85. On the western coast of Africa, at Sierra Leone, the dry season is from September to June, and the wet from June to October. About the end of June the rains increase, accompanied with dreadful storms of thunder and lightning.

On the gold coast, the rainy seasons last from April to October; and in the kingdom of Congo, from the end of March to the middle of September. The greatest quantity of rain generally falls about mid-day.

The seasons in the eastern coast are the reverse of those on the western: the winter, or rainy season, in Sofala, Mozambique, and Zanguebar, is from Septemper to February. In Egypt rain is a very uncommon phenomenon, yet a large portion of Grand Cairo was lately (1817) washed away by a dreadful torrent of rain.

In Abyssinia, the climate, though hot, is tempered by the mountainous nature of the country. From April to September, there are heavy rains. These rains, added to the melting of the snows on the mountains, occasion the overflowing of the Nile.

86. In Bengal, the hot or dry season begins with March, and continues to the end of May: the intense heat is sometimes interrupted by violent thunderstorms. The rainy season continues from June to September; the three last months of the year are

generally pleasant, but excessive fogs prevail in January and February. By the latter end of July, all the lower parts of Bengal are overflowed, and form an inundation of more than a hundred miles in width, nothing appearing but villages and trees, excepting, very rarely, the top of an elevated spot appearing like an island.

The chains of the Gauts, running from north to south along the western peninsula of India, intercept great masses of clouds, and produce opposite seasons on the coasts of Malabar and Coromandel. The rainy season, on the coast of Coromandel, is with the N. E. monsoon, or from October to April; and on that of Malabar with the S. W. monsoon, or from May to September. In the month of September the navigation on the Malabar coast is open, and ships begin to sail from the Malabar shore to all parts of the world.—The rains are not continual during the wet season, but pour down in floods for several days together, or for several hours in a day.

87. Peru is divided into two different climates by the Andes,—for whilst it is summer in the mountainous parts, it is winter in the vales. Winter, on the mountains, begins in December—but this in the vales is the first summer month; and a journey of four hours conducts the traveller from one season to another.

In general the confined regions on the west of the Andes are dry, whilst the wide countries on the east of that chain are deluged with torrents of rain, from the trade winds blowing over the Atlantic.

Travellers, on the Andes, have sometimes enjoyed a delightful serenity in these elevated regions, at the same time that they have heard the horrid noise of tempests discharging themselves on the level country: they have seen lightnings issue from the clouds, and heard the thunders roll far beneath their feet.

At Lima, rain is seldom or never seen, but a strong dew falls and waters the vallies. The country is much subject to earthquakes; the most dreadful seems to have been that of 1747, when the port of Callao was submerged, and out of 4000 inhabitants only 200 escaped.

In Brazil the wet season commonly begins in

March or April, and is over in August; when the spring, or rather the summer, begins. The nights are very cold; and the nights in summer are colder than in winter.

In Jamaica the rain commonly begins in May. July is always very wet; and toward the end of that month, and the beginning of August, the weather is very close. In September and October hurricanes are frequent.

In Nicaragua it rains six months, from the first of May to the first of November; in the other six months it is hot and dry.

88. That part of the frigid zone which is inhabited, viz. Greenland, Lapland, &c. has only two seasons, winter and summer. Their night of winter, the sun never appearing above the horizon, is extremely severe.

The most rapid rivers are sometimes frozen five or six feet deep or more; the largest lakes and bays are frozen to bear any weight, and rocks often burst by the intensity of the frost. The brilliancy of the stars, the Aurora Borealis, and the full moon, which never sets, make some atonement for the absence of the sun. The long twilight also, which they enjoy before the sun rises and after he sets, considerably diminishes the time of their total darkness.

The transition from winter's frost to summer's heat is very rapid in the frigid zone. The short summer is very warm, but foggy. The continual sunshine now enables the inhabitants to lay up a store of provisions for winter.

89. The hottest part of the earth is in the middle and western parts of Africa. The trade winds, in passing over the extensive sandy deserts of this continent, become heated to an extreme degree before they arrive at the western coast.

The climate, on the western continent, is much colder than it is in similar parallels on the eastern continent.

Canada, in North America, which is nearly in the same parallel with France, has the winters almost as severe as at

Petersburg: the river St. Laurence, notwithstanding its breadth, is frequently frozen the whole of the winter, strong enough to bear even carriages upon it. Philadelphia and New York, nearly in the same parallel with Madrid, have often severe winters, but the heat of the summer is excessive.

The cold in the southern hemisphere is much greater than in the northern. The climate of Terra del Fuego is an instance of this: situated as far south as Newcastle is north of the equator; and, therefore, were the degrees of heat and cold proportionable to the latitude, we might expect the summers of Terra del Fuego as warm as those on the banks of the Tyne; yet Captain Cook, who was there at Midsummer, found the cold so excessive, that a party botanizing on the hills, was in danger of perishing by cold.

The mountains and vast fields of ice, around the South Pole, extend to a much greater distance than those around the North Pole. Navigators have penetrated to within 9 degrees of the North Pole; yet Captain Cook could not get nearer the South Pole than within 18 degrees.

90. In great Continents the weather is more settled than it is in islands: the summer's heat is greater, and the winter's cold is more intense.

In islands the heat is tempered by clouds and vapours from the surrounding sea; but the weather is inconstant. The cold of winter is also mitigated from the same cause, and the frost is generally of short duration. This is particularly the case with respect to Great Britain.

SECTION V.

GEOGRAPHICAL PHENOMENA.

Of Winds.

91. THE wind is nothing else but the air put violently in motion; and this is occasioned chiefly by means of heat. For, when any part of the air is heated by the sun, or otherwise it will swell, and thereby affect the adjacent air; and so, by various degrees of heat in different places, there will arise various motions of the air.

When the air is much heated, it will ascend towards the upper part of the atmosphere, and the adjacent air will rush in to supply its place; and therefore there will be a stream or current of air from all parts, towards the place where the heat is. And hence we see the reason, why the air rushes with such force into a glass-house, a tile-kiln, or towards any place where a great fire is made; and also why smoke is carried up a chimney, and why the air rushes in at the key-hole of a door, or any small chink, where there is fire in the room. In general, we may take it for granted, that the air will press towards that part of the world where it is most heated.

92. The winds are divided into four principal ones, the *north, south, east,* and *west,* which receive their names from the four quarters of the world.

From the *Frigid Zone* comes the north wind, which is consequently the coldest.

The *south wind* is the warmest, and particularly in the summer, because it comes from the *Torrid Zone,* over countries where the sun is most vertical.

The *east wind* is the dryest, because it comes across the vast continent of Asia, which is but little watered by rivers or seas.

The *west wind* often blows us rain; because, as it crosses the great Atlantic ocean, it attracts a great quantity of vapours.

When these impetuous winds happen to meet, the greatest inconveniences follow. The sulphureous exhalations from the south, torrents of nitre from the north, and watery vapours from every side, become indiscriminately blended together in one confused mass. From hence proceed tempests, thunder, rain, hail, and whirlwind.

93. The velocity of wind is at the rate of 50 or 60 miles an hour, in a great storm; that of a common brisk wind is about 15 miles an hour; and some winds move not even one mile in that space of time.

A person, therefore, on horseback, and even sometimes on foot, may be said to outstrip the wind; for, if he moves faster than the wind, which is very possible, he will have a wind in his face, though he move in the same direction with the wind.

The velocity of *sound* is *thirteen* times as great as that of the strongest wind.

Of the Tropical Winds.

94. There are certain winds, called tropical winds, which blow almost always from the same point of the compass. They are of three kinds.

The *general trade winds,* which extend to nearly thirty degrees of latitude on each side of the equator, in the Atlantic, Ethiopic, and Pacific oceans. On the north side of the equator, they blow from north-east, on the south side, from the south east, and near the equator from almost due east.

The *monsoons,* or shifting trade winds, which blow six months in one direction, and the other six months in the opposite direction. These are mostly in the Indian, or Eastern ocean, and do not reach above two hundred leagues from the land. Their change is at the vernal and autumnal equinoxes, and it is accompanied with terrible storms of thunder, lightning and rain. The monsoons are occasioned by the *cold air* moving towards those places, in which the air is rarefied by the heat of the sun, in order to restore its equilibrium.

The *land and sea breezes,* which are periodical winds, and blow from the land, from night to about mid-day, and from the sea, from about noon to midnight. These winds do not extend above two or three leagues from the shore.

Beyond the latitude of thirty degrees, north and south, the winds, as we daily perceive in Great Britain, are more variable, though it may be observed, in general, that the tendency of the wind is from a colder region to that which is hotter.

Of the Aurora Borealis.

95. In illustrating the two seasons of the year in the frigid zone, (north); we had occasion to mention the benefit derived from the *Aurora Borealis.*

That shining light which is often seen by night in the heavens, and which is vulgarly called the northern lights, or streamers, is the *Aurora Borealis,* which, till the month of March, 1716, was not much observed in England.

This phenomenon is supposed to be the result of electrica fluid passing from one region to another; though some have strangely enough supposed it to be produced by nitrous and sulphureous vapours thinly spread through the atmosphere and above the clouds, where they ferment, and taking fire, the explosion of one portion kindles the next, and the flashes succeed one another till all the vapour is set on fire. But we know sufficient of the electric fluid's powers and operations not to believe it the cause of those streams of light, which under the name of the Aurora Borealis, seem to converge towards the zenith of the spectator, or to that point of the heavens which is immediately over his head.

Now black, and deep, the night begins to fall,
Drear is the state of the benighted wretch,
Who then, bewilder'd, wanders through the dark,
Perhaps, impatient as he stumbles on,
Struck from the root of slimy rushes, blue,
The wild fire scatters round, or gather'd, trails
A length of flame deceitful o'er the moss:
Whither decoy'd, by the fantastic blaze,
Now lost, and now renew'd, he sinks absorpt,
Rider and horse, amid the miry gulf:
At other times, gleaming on the horse's mane,
The meteor sits; and shows the narrow path,
That winding, leads through pits of death; or else,
Instructs him how to take the dangerous ford.

THOMSON.

Of Refraction.

96. The earth is surrounded by a body of air called the atmosphere, through which the rays of light come to the eye from all the heavenly bodies; and since these rays are emitted through a very rare medium, and fall obliquely upon the atmosphere, which is a dense medium, they will, by the laws of optics, be refracted in lines approaching nearer to a perpendicular from the place of the observer (or nearer to the zenith,), than they would be were the medium to be removed.

Hence all the heavenly bodies appear higher than they really are, and the nearer they are to the horizon the greater the refraction, or difference between their apparent and true altitudes will be; at noon the refraction is the least. The sun and the moon appear sometimes of an oval figure near the horizon, by reason of the refraction: for the under side being more refracted than the upper, the perpendicular diameter will be less than the horizontal one, which is not affected by refraction.

Of Twilight.

97. The *Crepusculum,* or *Twilight,* is that faint light which we perceive before the sun rises and after he sets. It is produced by the rays of light being refracted in their passage through the earth's atmosphere, and reflected from the different particles thereof.

The twilight is supposed to end in the evening when the sun is 18° below the horizon, or when stars of the sixth magnitude (the smallest that are visible to the naked eye) begin to appear; and the twilight is said to begin in the morning, or it is *day-break,* when the sun is again within 18° of the horizon. The twilight is the shortest at the equator, and longest at the poles; here the sun is near two months before he retreats 18° below the horizon, or to the point where his rays are first admitted into the atmosphere; and he is only two months more before he arrives at the same parallel of latitude.

This may be illustrated on the globe without a diagram.

SECTION VI.

OF THE TIDES, AND THE SALTNESS OF THE SEA, AND TEMPERATURE.

98. As rivers flow and swell, so also does the sea. Like them it has its currents, which agitate its waters, and preserve them from putrefaction. That regular motion of the sea, according to which it ebbs and flows twice in about twenty-four hours, is called its *tides.*

In its flux, the sea generally rises for about six hours, when it remains, as it were, suspended, and in equilibrio, for some minutes. At that time it is called *high water.*

In its reflux, the sea falls for about six hours, when it remain, as it were, in a like manner, suspended, and in equilibrio, for some minutes. At that time it is called *low water.*

Obs. 1. We are told that Aristotle, despairing to discover the true cause of these wonderful appearances, had the folly, in spite of his philosophy, to throw himself headlong into the sea.

The *tides* are occasioned by the *attraction* of the *moon*. This doctrine remained in obscurity, till Newton explained it by his great principle of gravity or attraction

Since the power of gravity diminishes as the squares of the distances increase, the waters on one side of the earth are more attracted by the moon, than the waters toward the central parts of the earth, and the central parts are more attracted than the waters on the opposite surface of the earth: hence, the waters on the one side will be attracted less than the centre, or will recede from thence. Hence, the form of the water on the surface of the earth will become an oblong spheroid.

This oval of the waters keeps pace with the moon in its monthly course round the earth; while the earth by its daily rotation on its axis, presents each part of its surface to the direct action of the moon, twice every day, and thus produces two flood and two ebb tides. But because the moon is in the mean time passing from east to west in its orbit, it comes to the meridian of any place later than it did the preceding day; consequently the two floods and ebbs require nearly 25 hours to complete them. The tide is not at the greatest height, when the moon is in the meridian, but some time afterwards, because the force by which the moon raises the tide continues to act for some time after it has passed the meridian.

As the moon thus raises the water in one place, and depresses it in another, the sun does the same; but in a much less degree, on account of the small ratio of the semi-diameter of the earth to the distance of the sun.

The genius of the student will dictate the diagram of this scheme from my description, which is at once popular and scientific.

The tides are greatest at the new and full moons, and are thence called spring tides, and least at the first and last quadratures, and are thence called neap tides, and the highest tides are near the time of the equinoxes.

On the full and new moons, which happen about the equinoxes, when the luminaries are both in the equator or near it, the tides are the greatest: for example, the two eminences of water are at the greatest distance from the poles, and hence the difference between ebb and flood tide is more sensible; for if those eminences were at the poles, it is obvious we should not perceive any tide at all: again, if the equatorial diameter of the earth be produced, it passes through the moon, which diameter is longer than any other, and, consequently, there is a greater disproportion between the distances of the zenith, centre, and nadir, from the centre of gravity of the earth and moon, in this situation, than in any other: finally, the water rising higher in the open seas, rushes to the shores with greater force, where being stopped, it rises higher still; for it not only rises at the shores in proportion to the height to which it rises in the open seas, but also according to the velocity with which it flows from thence against the shore. The spring tides which happen a little before the vernal and after the autumnal equinox, are the greatest of all, because the sun is nearer the earth in the winter than in the summer.

When the moon is in the northern hemisphere, it produces a greater tide while it is in the meridian above the horizon, than when it is in the meridian below it; when in the southern hemisphere, the reverse is the case.

For the like reason, when the moon is in the southern signs, the greatest tides on the other side of the equator will be when it is below our horizon, and the least tides when it is above it.

These things would happen uniformly, were the whole surface of the earth covered with water; but since there is a multitude of islands and two vast continents, which interrupt the natural course of the water, a variety of appearances are to be met with in different places, which cannot be explained, without regarding the situation of shores, shoals and other objects, which contribute in producing those appearances.

There are frequently streams or currents in the ocean, which set ships a great way beyond their intended course. There is a current between Florida and the Bahama islands, which always runs from north to south. A current runs constantly from the Atlantic, through the straits of Gibraltar, into the Mediterranean. A current sets out of the Baltic sea, through the sound or strait between Sweden and Denmark, into the German ocean; so that there are no tides in the Baltic.

About small islands and head-lands in the middle of the ocean, the tides rise very little; but in some bays, and about the mouths of rivers, they rise from twelve to fifty feet.

Perhaps it may be said, that as a current constantly runs from the Atlantic into the Mediterranean, the waters of that sea ought to increase. By no means. The water extracted from it in vapours, is more than sufficient to counterbalance the influx. It has been found by calculation, that in a summer's day, there may be raised in vapours, from the Mediterranean, 5280 millions of tuns of water. Yet this sea does not receive, from all its nine great rivers, above 1827 millions of tuns per day, which is but one-third of what is exhausted in vapours; so that, were it not for the influx from the Atlantic, the Mediterranean would soon be rendered dry.

The tides flow from *east* to *west*, for they must necessarily follow the moon's motion, which is from east to west.

* The course of the tides, however, is sometimes *interrupted* by continents, and other large tracts of land. The tide, for instance, in the Indian ocean, being stopped by the eastern coast of Africa, must necessarily flow south, towards the Cape of Good Hope, which having passed, it then runs northward along the Western coast of Africa, to that of Spain, Portugal, and France, till it enters the English channel; there meeting the tide from the German ocean, running a contrary way, it is necessarily stopped, and produces a very great swell of of water.

These *two tides* thus flowing in opposite directions, and meeting a little irregularly, have sometimes occasioned *two tides*, the one immediately after the other, in the river *Thames*, which, though proceeding from a natural cause, and consequently very easy to be explained, has been looked upon as a prodigy.

As to the tide of rivers, it must always flow in a direction quite the reverse of their natural stream; for the waters of the sea being higher, they must necessarily flow into them, and make their waters flow back, or regurgitate. The tide of the Thames, and of all the other rivers on the eastern coast of England, must flow westward. The tide of the Severn, and of all the other rivers on the western coast of England, must run eastward; and so of the rest.

Luminous appearance of the Surface of the Sea.

99. Dr. Robertson, in his observations on the tides of the Mediterranean, says, " I have often remarked

the very luminous appearance of its waters on the slightest agitation." This phenomenon is frequently perceived after sunset, especially during the warm season. By many people it has been supposed to be caused by certain minute luminous insects existing in the water,—to the disengagement of phosphorus from the excrements or remains of fishes that have died, and other putrid matters.

By seamen, this luminous appearance from the slightest agitation, has been considered as generally the precursor of blowing weather, and I am persuaded from repeated observation, that the remark is as correct as it is general. This luminous appearanee is but rarely met with during the winter season, compared to the frequency with which it occurs in the summer and autumn. I have never seen it when the wind blows fresh from a northerly point, or when the temperature of the air is low; nor have I remarked it in any great degree, but in calm weather, when the temperature of the air was high, and especially as the wind was changing towards a southerly point, and I have always observed that this luminous matter was emitted most strongly immediately preceding the fall of rain or an overcasting of the sky, shewing a disposition to the formation of that meteor.

Upon the whole, I am of opinion, that this apearance of light on the agitation of the waters of the Mediterranean, is somehow or other connected with evaporation, and that it is occasioned by the rapid evolntion of the electric fluid in that process; that it rarely depends on phosphoric matters existing in the waters; and after repeated and careful observations by myself and others, I have never been able to trace its appearance as depending on the existence of insects, nor could I ever perceive any thing peculiar in the sensible qualities of water taken up in such circumstances, or that was different from water of the sea when it did not give out this luminous appearance. Moreover, as this appearance is only perceived on the agitation of the water, it would therefore seem that the luminous matter, whatever it may be, does not depend on a matter that is merely blended or mixed in the water, as in such a state, its appearance would be equally manifest in a calm, as when there is a gentle ripple on the surface; and it must have been equally discernible in all conditions of the weather; and what I consider as tending to corroborate my opinion, that the electric fluid is generally the cause of this shining appearance, an ingenious Greek physician informed me that he found it always extremely difficult to accumulate the electric fluid in his apparatus on such occasions.

On the Saltness of the Sea.

100. Sea water is salt, while that of rivers is mild, fresh, sweet, and fit for human purposes. Some think that this saltness arises from great beds of salt lying at the bottom of the sea. But others, more rationally suppose it is owing to the following cause. Salt is one of the original principles of nature, and is mixed, in greater or less quantities, with most other bodies.

Now all rivers run into the sea, and carry some salt with them; but no rivers run out of it, nor is any water taken from it, except by exhalation or evaporation. But chemists have demonstrably proved, that no salt can ascend in either of these ways; and consequently, all the salt carried into the sea by the immense numbers of rivers that run into it, remains behind, and occasions its saltness.

That no salt ascends from the sea, either by exhalation or evaporation, is evident from this, that rain-water, which falls from the clouds, and which was originally exhaled from the sea, is, of all kinds of water, the sweetest, purest, and lightest, and is made the standard by which philosophers judge of all other waters.

The water of the ocean contains about the 30th part of its weight of salt: the water of the Baltic holds only from the 200dth to the 100dth part, consequently the water of the Baltic ought to stand 1-40th part higher from the bottom of the sea, than the water of the ocean, in order to maintain its hydrostatic equilibrium. It is observed on the Baltic shores, that the water subsides, and that its surface is lower in all parts than it formerly was. May not this be in consequence of the Baltic becoming salter, and thus approximating to the specific gravity and height of the ocean?

Of the Origin of Springs and Rivers.

101. Various opinions have been held by ancient, as well as modern philosophers, respecting the origin of springs and rivers: but the true cause is now pretty well ascertained. It is well known that the heat of the sun draws vast quantities of vapour

from the sea, which being carried by the wind to all parts of the globe, and being converted by the cold into rain and dew, it falls down upon the earth; part of it runs down into the lower places, forming rivulets; part serves for the purposes of vegetation, and the rest descends into hollow caverns within the earth, which breaking out by the sides of the hills forms little springs; many of these springs running into the valleys increase the brooks or rivulets, and several of these meeting together make a river.

I see the rivers in their infant beds!
Deep, deep I hear them lab'ring to get free;
I see the leaning strata, artful rang'd:
The fissures gaping to receive the rains,
The melting snows, and ever-dripping fogs.
Strew'd bibulous above, I see the sands;
The pebbly gravel next, the layers then
Of mingled moulds, of more retentive earths.
The gutter'd rocks, and mazy-running clefts,
In pure effusion flow. United, thus
Th' exhaling sun, the vapour-burden'd air,
The gelid mountains, that to rain condens'd
These vapours in continual current draw,
And send them, o'er the fair-divided earth,
In bounteous rivers to the deep again;
A social commerce holding firm support.

THOMSON.

Dr. Halley says, the vapours that are raised copiously from the sea, and carried by the winds to the ridges of mountains, are conveyed to their tops by the current of air; where the water being presently precipitated, enters the crannies of the mountains, down which it glides into the caverns, till it meets with a stratum of earth or stone, of a nature sufficiently solid to sustain it. When this reservoir is filled, the superfluous water, following the direction of the stratum, runs over at the lowest place, and in its passage meets perhaps with other little streams, which have a similar origin; these gradually descend till they meet with an aperture at the side, or foot, of the mountain, through which they escape, and form a spring, or the source of a brook or rivulet. Several brooks or rivulets, uniting their streams, form small rivers, and these again being joined by other small rivers, and united in one common channel, form such streams as the Rhine, Rhone, Danube, &c.

Several springs yield always the same quantity of water, equally when the least rain or vapour is afforded, as when rain falls in the greatest quantities; and as the fall of rain, snow, &c. is incontant or variable, we have here a constant effect produced from an inconstant cause, which is an unphilosophical conclusion. Some naturalists, therefore, have recourse to the sea, and derive the origin of several springs immediately from thence, by supposing a subterraneous circulation of percolated waters from the fountains of the deep.

Sources of the Rivers Ganges, Jumna, and Bhagirutta.

102. These immense rivers take their rise in the heart of the stupendous Himalaya mountains, situated in the Nepaul country; and the following is an account of Captain Hodgson's tour to discover their sources.

Captain Hodgson left Reital;—a village consisting of 35 houses two or three stories high, and built of wood, (in latitude 30° 48′ N.),—on the 21st of May, 1817. On the 31st he descended to the bed of the river, and saw the Ganges issue from under a very low arch, at the foot of the grand snow bed. The river was bounded on the right and left by high rocks and snow, but in front over the debouchee, the mass of snow was perpendicular, and from the bed of the stream to the summit, the thickness was estimated at little less than 300 feet of solid frozen snow, probably the accumulation of ages, as it was in layers of several feet thick, each seemingly the remains of a fall of a separate year.

From the brow of this curious wall of snow, and immediately above the outlet of the stream, large and hoary icicles depended. The height of the arch of snow is only sufficient to let the stream flow under it.—Blocks of snow were falling on all sides, and there was little time to do more than to measure the size of the stream; the main breadth was twenty-seven feet, the greatest depth about eighteen inches, and the shallowest part nine or ten inches. Captain Hodgson believes this to be the first appearance in day-light of the celebrated Ganges! The height of the halting-place, near which the Ganges issues from under the great snow-bed, is calculated to be 12,914 feet above the sea.

At Jumnoutri, the visible source of the river Jumna, the snow which covers and conceals the stream is about sixty yards wide, and is bounded on the right and left by precipices of granite 40½ feet thick, which have fallen from the precipices above. Captain Hodgson was able to measure the thickness of the bed of snow over the stream very accurately by means of a plumb-line let down through one of the holes in it, which are caused by the steam of a great number of boiling springs at the border of the Jumna.

The head of the Jumna is on the S. W. side of the grand Himalaya ridge, differing from the Ganges inasmuch as that river has the upper part of its course within the Himalaya, flowing from south-east to north-west, and it is only from Sookie, when it pierces through the Himalaya that it assumes a course of about 20 south west. The mean latitude of the hot springs of Jumnoutri appears to be 30,58.

After descending into the bed of the Bhagirutta, that river was also traced nearly to its source: the glen through which it runs is deeper and darker, and the precipices on either side far more lofty than those forming the bed of the Jumna: the rock in the neighbourhood of its source was granite, and contained black tourmaline.

Note. As various other interesting subjects connected with this earth on which we live will crave our attention under separate titles of this work, we reserve these for their proper places, as scientific arrangement is absolutely necessary if we would travel nature's variegated regions without blindness or irregularity.

Temperature.

103. Temperature is dependent on the depth of the atmosphere, and the direction of the solar rays; hence the *great heat* experienced under a deep atmosphere, and vertical sun; the *mild temperature* under one moderately high, combined with rather oblique rays; and the *intense cold* in and near the polar regions, where the atmosphere is shallow, and the rays very oblique.—*Water*, in high latitudes is colder, and consequently heavier, bulk for bulk, than in warm climates; hence the constant currents from the polar regions towards the equator, and the flowing of cold seas into those that are warmer.

In winter, the ocean, from 70° *n.* to the equator, is seldom cooler than 4° below the freezing point; the inland countries, from 49° *n.* to 7° *n.* are frequently cooled to 40°, 50°, and sometimes 70° below the freezing point: consequently the ocean winds, at this season, are warmer than those from the land. In summer, land is heated above the temperature of the ocean, but no considerable tract of land is heated to above 15° or 20° more than the ocean, stony and sandy deserts excepted: therefore the land winds, at this season, are warmer than the ocean winds. —*Seas*, in general, if not surrounded with high mountains, are a few degrees warmer in summer, and cooler in the winter, than the ocean; in high latitudes they are frequently frozen: the *British sea* is about 3° degrees cooler in winter, and 3° warmer in summer, than the ocean is. The *Mediterranean* is at all seasons warmer than the ocean; hence the atlantic flows into it. The *White sea* is frozen in winter; the *Baltic* is almost wholly frozen; the northern parts of the *Gulf of Venice* are sometimes frozen; many parts of the *Black sea* and the *sea of Azoph* are frozen; the waters of the Black sea flow into the Mediterranean; the chief part of the *Caspian Sea* is frozen, though it is said by Pallas to be lower than the ocean.—*Snow* is perpetual in the *torrid zone* at the elevation of 5233 yards above the level of the ocean; under the *tropics* at 5000 yards; in the middle latitudes at 2325 yards; in the latitude of 80° at 400 yards.

SECTION VII.

OF THE PRODUCTIONS, INHABITANTS, RELIGIONS, AND GOVERNMENTS OF THE EARTH.

104. ALL natural productions are arranged under three grand classes, called KINGDOMS; 1. the *mineral*; 2. the *vegetable*; and 3. the *animal kingdom.*

The *Mineral* kingdom contains, 1. all earths and stones; 2. mineral combustibles; 3. salts; and 4. metals.

The *vegetable* kingdom includes all trees, shrubs, and plants, whether in the ocean, or on the land; hence we speak of *marine* and *terrestrial* vegetables.

The *Animal* kingdom contains all living creatures, as 1. quadrupeds; 2. bipeds; 3. fowls; 4. fishes; 5. Reptiles; 6. insects; 7. worms.

Man, the chief of the world, is the noblest of all God's creatures. The faculties of reason and speech distinguish him as lord of the creation: and his progressive improvement distinguishes his pre-eminence above all other animals.

Religion.

105. There is one God; to love and worship him is true religion.

To worship any created substance is paganism or idolatry.

With respect to worship, men may be divided into *Christians, Mahometans, Jews,* and *Pagans:* and subdivided into sects.

The principal of the Christian sects are *Protestants, Papists,* and the *Greek Church.*

The *Christians* believe in Jesus Christ: the *Mahometans* in Mahomet; the *Jews* acknowledge neither, but still expect the Messiah.

The Christians have the *Scriptures* for their guide;—the Mahometans, the *Koran:*—the Jews, *the Bible.*

Christians are numerous in Europe, and America, some in the south of Asia, and a few in Africa.

Mahometans are numerous in Asia, *Africa,* and the south-east of Europe.

Pagans abound in Africa and in the interior of America, some in Asia, and a small number in the north of Europe.

People.

106. 960 millions of human beings are supposed to be upon the earth; of which, *Europe* is said to contain 153 millions—*Africa,* 150,—*Asia,* 500,—*America,* 150,—and the islands in the Pacific, 7.

If divided into 30 equal parts, 5 of them will be Christians, 6 Mahometans, 1 part Jews, and 18 Pagans.

Governments.

107. A government may be either Monarchical, aristocratical, democratical, or mixt.

In a *monarchy* one man governs.
In an *aristocracy* the nobles govern.
In a *democracy* the people rule.

A *mixt* comprises the preceding, such is the Government of Great Britain and Ireland.

A monarchical government is limited or unlimited; *limited*, as in the British empire; *unlimited*, in the rest of Europe.

CHAPTER V.

REFINING METALS.

108. REFINING implies the purification of some substance. As we use the term it signifies the separation of gold, silver, and copper, from each other, and obtaining each metal in its pure state.

SECTION I.

CUPELLATION.

109. Gold and silver are called *perfect* metals, because they are capable of withstanding the action of very strong heat. All other metals are reduced to the state of oxydes when subject to fire with access of air. Gold and silver may therefore be purified from baser metals, by keeping them melted till the alloy be destroyed. But this process is tedious and expensive, from the great consumption of fuel. A shorter and more advantageous method of refining gold and silver has been discovered,

A certain quantity of lead is put into the crucible with the alloy of gold and silver, the whole is exposed to the action of the fire; and the lead being quickly converted by heat into an oxyde, which is easily melted into a semi-vitrified, and powerful vitrifying matter, called litharge, we have only to increase the proportion of imperfect metals, the litharge will prevent them from being so well covered and protected by the perfect metals; and by uniting with these imperfect metals; it communicates to them its property of being very easily oxydated. By its vitrifying and fusing property, exercised with force upon the calcined and naturally refractory parts of the other metals, it accelerates the fusion, scorification, and separation of these metals. In this operation the lead is scorified, and scorifies along with it the imperfect metals. It separates from the metallic mass, floats upon the surface of the melted mass, and becomes vitrified. But as the litharge would soon cover the melted metal, and by preventing the access of air, prevent the oxydation of the remaining imperfect metals, such vessels are employed as are capable of imbibing and absorbing in their pores the melted litharge, and thus removing it out of the way. Or, for large quantities, vessels are so constructed, that the fused litharge, besides being soaked in, may also drain off through a channel made in the corner of the vessel.

Vessels made of lixiviated wood, or bone-ashes, are most proper for this purpose. These vessels are called *cupels,* the process itself *cupellation.* The cupels are flat and shallow. The furnace should be vaulted, that the heat may be reverberated upon the surface of the metal during the operation.

A crust, or dark coloured pellicle is continually forming upon the surface. When all the imperfect metal is destroyed, and the scorification has ceased, the surface of the perfect metal is seen clean aud brilliant, forming a kind of fulguration, called lightning. By this mark, the metal is known to be refined.

Purification of Gold by Antimony.

110. When gold contains but a small quantity of alloy, it may be separated from the base metal by melting it in a crucible that will hold twice its quantity, throwing upon it, whilst in fusion, double its weight of crude autimony (sulphuret of antimony). The crucible is then covered, and the whole kept in a state of fusion for some minutes; and when the surface sparkles, it is poured into an inverted cone, which has been previously heated and greased. By striking the cone on the ground, the metal will come out when cold.

The mass consists of two substances; the upper part being the sulphur of the crude antimony, united with the impure alloy; and the lower part gold, united to some of the regulus of antimony. This gold may be separated from the regulus of antimony by exposure to less heat than will melt the gold, because antimony is volatile and dissipates in such a heat. If the gold is not sufficiently purified by this first process, repeat it a second, and even a third time. When a part has been dissipated, more heat is required to keep the gold in fusion; the fire must therefore be increased towards the conclusion of the operation. The purification may be completed by throwing into the crucible, a little crucible, which effectually calcines the remaining regulus of antimony. If, after these operations, the gold be deprived of its usual ductility, this may be restored, by fusing it with nitre and borax.

The sulphur of the antimony, though it unites with the basest metals, does not destroy them, but forms with them a scoria, from which they may be separated by treatment as an ore.

Diagrams of crucibles are unnecessary; every one knows that a crucible is shaped like a wine glass.

SECTION II.

PARTING.

111. When the quantity of silver mixed with the gold is considerable, they may be separated by other processes. Nitric acid, muriatic acid, and sulphur, which cannot dissolve gold, attack silver very easily; these three agents furnish methods of separating silver from gold and the operation is called *parting*.

Parting by nitric acid being the most convenient, is almost the only one employed by goldsmiths and coiners who call it simply, *parting*. That performed with muriatic acid is only made by cementation, and receives the name of *concentrated parting*. Lastly, parting by sulphur is effected by fusion; it is called *dry parting*.

Parting Gold from Silver by Nitric Acid.

112. Though parting by nitric acid be easy, it cannot succeed exactly unless we attend to some essential circumstances. The gold and silver must be in a proper proportion; for if the gold be in too great a

quantity, it would cover the silver and guard it from the action of the acid; therefore when assayers know not the proportions of gold to silver in the mass, they rub the mass on a *touch-stone* of black basaltes, so as to leave a mark upon it; they then make similar marks with their *proof-needles* (needles composed of gold and silver alloyed in graduated proportions), and by comparing the colour of the several marks, they discover the probable scale of admixture.

If the trial shews, that in a given mass the silver is not to the gold as three to one, it will not serve for the operation of parting by aqua-fortis, and the quantity of silver necessary to make an alloy of that proportion, must be added. This operation is called *quartation*, because the gold is reduced to a fourth of the whole mass. No inconvenience arises from the quantity of silver being too great, except a waste of aqua-fortis. The nitric acid or aqua-fortis employed, must be pure, and free from sulphuric and muriatic acids. Its purity must therefore be ascertained; and if this be found not sufficient, the acid must be purified by nitrate of silver.

If the purity of the nitric acid were not attended to, a great quantity of silver proportionable to these two foreign acids, would be separated during the solution; and this portion of silver converted by these acids to sulphate of silver, and to muriate of silver, would remain mingled with the gold.

When the metallic mass is properly alloyed, it is to be reduced to plates, called *cornets*, or to grains, rolled up spirally. These are put into a matrass, and upon them there is poured a quantity of aqua-fortis, whose weight is to that of silver as three to two; and as the nitric acid employed for this operation is weak, the solution is at first assisted by the heat of a sand-bath, on which the matrass is placed.

When, no further mark of solution appears, the aqua-fortis charged with silver is decanted. Fresh nitric acid stronger than the former, but in less quantity, is poured into the matrass. This is boiled in the remaining mass, and decanted as the former. Aqua-fortis must be boiled a third time on the remaining gold, that all the silver be dissolved. The gold then washed with boiling water, is very pure, if the operation has been performed with due attention. It is called *gold of parting*.

The silver dissolved in aqua-fortis, may be separated by distillation. In this case all the aqua-fortis is recovered pure, and fit for another parting. Or it may be precipitated by some substance having a greater affinity than this metal with nitric acid. In the ascent copper is generally employed for this purpose.

The solution of silver is put into copper vessels. The aqua-fortis dissolves the copper, and the silver precipitates; the new solution being decanted, is then a solution of copper. The precipitate is well washed, and melted into an ingot, called *parted silver*.

When this silver has been obtained from a mass which had been refined by lead, and when it has been well washed from the solution of copper it is very pure. Or the silver may be separated from the nitric acid by adding to it muriatic acid, with which it forms muriate of silver. Muriate of silver may be decomposed by mixing it with soder, and exposing it to a sufficient heat in a crucible, by this means the soder unites to the muriatic acid, and sets the silver free.

VERDITER. The refiners frequently employ this solution of copper obtained in the process of parting, for making *verditer;* which is prepared by adding quick lime to the solution; a precipitate takes place, which is the blue pigment known by the name of verditer.

Parting Gold from Silver by Cementation.

113. This is also called concentration, when the quantity of gold is so great to that of the silver, as to render it a difficult task by aqua-fortis. The mixed metal to be cemented is reduced to plates, as thin as small pieces of money. At the bottom of the crucible, or melting-pot, is laid a stratum of cement, composed of four parts of brick dust, one part of green copperas (sulphate of iron) calcined to redness, and one part of common salt, about the thickness of a finger in depth. Upon this stratum a layer of plates of the metal is placed, and then another stratum of cement, and so on till the crucible is filled. It is now placed in a furnace, or oven (after a top has been luted on the crucible), and exposed for twenty-four hours, till it becomes red hot, but not melted. The fire is now left to go out, and the the metal to cool, that it may be separated from the cement, and boiled repeatedly in pure water. This gold is afterwards tried on a touchstone; and if not sufficiently purified, the process is performed a second time.

By the above method, we see how powerfully silver is dissolved by marine acid, when in a state of subtile vapour, that has been disengaged from the common salt of the cement. Nitre may be used instead of common salt, as the nitrous acid readily dissolves silver; but the mixing of common salt and nitre together is highly injudicious, because the joint acids are able to dissolve some of the gold with the silver. Whatever silver has been separated will now remain in the cement; but it may be freed from this by lead, in the method described in cupellation.

Parting Gold from Silver in the dry Way.

114. This called also *parting by fusion*, is performed by means of sulphur, which has the property of uniting easily with silver, while it does not attack gold. This dry parting, is troublesome, and expensive, and is not undertaken but when the silver far exceeds the gold, because sulphur will not separate it so easily as aqua-fortis, and will therefore require a further application to cupellation and solution.

Refining Silver by Nitre.

115. The principle of this operation is founded on the property of nitre to oxydate very powerfully all base metals; whereas the precious metals are not affected by it. For as the metallic oxydes and glasses, remain not united with reguline metals, and as these latter when in fusion, sink to the bottom,

on account of their greater specific gravity, they may be easily parted from the scoria.

The silver to be purified by nitre is first granulated, then mixed with a fourth part of its weight of dry nitre, an eighth part of potash, and a little common glass, all in powder. This mixture is put into a crucible, two-thirds full. The crucible is covered with a smaller crucible inverted, in the bottom of which a small hole has been made. Both are luted and placed in a furnace capable of drawing air to make the fire intense enough to melt the silver. Then into the furnace, charcoal is put to such a height, that only the top of the inverted crucible shall be uncovered. The coal is then kindled, and the vessels made moderately red, and a hot coal put upon the small hole in the bottom of the inverted crucible. If a shining light be observed round this coal, and a slight hissing noise at the same time heard, the operation proceeds well. The fire is now sustained at the same degree till these appearances cease, when it is encreased, so that the silver be well melted, and then the crucibles are taken out of the furnace. The large crucible is broken when it is cold, and the silver will be found at the bottom covered with green alkaline scoria.

Some silver is apt to be lost in this operation, by the swelling and detonating of the nitre, which often forces it through the hole in the upper crucible, unless great care be used; this method has, however, its advantages, being more expeditious than cupellation.

Separating Silver from Copper by Eliquation.

116. When, in the large way, it is desired to separate a small quantity of silver from much copper with which it is alloyed, the process called *eliquation* is resorted to. This operation depends on the nearer affinity of silver with lead than with copper; hence, it fuses, and combines with lead at a degree of heat in which copper does not fuse.

Whitening Silver by Boiling.

117. The whitening of silver by boiling is one of the methods of parting copper from silver in the humid way. The silver wrought in any shape is first ignited to redness, then boiled in a ley of muriate of soder and acidulous tartrate of potash, and by so doing the copper is removed from the surface, and the silver receives a whiter appearance.

Precipitating Silver by Copper.

118. Copper has a much greater affinity with oxygen than silver; hence, the silver is precipitated from its solutions as a fine *silver dust,* by metallic copper. This likewise affords a means of discovering what portion of silver may be contained in an alloy of silver and copper. A quantity of the mixture determined by weight is dissolved in nitric acid; the solution is diluted with filtered water, and a plate of copper hung in it, till no more precipitate. The weight of the precipitate, when edulcorated, is then compared with that of the whole alloyed metal put to trial.

This silver dust, well washed and mixed with gum water, is used in water painting.

Separating Silver from Copper by an Alkaline Sulphuret.

119. The affinity of copper with sulphur is stronger than that of silver, hence, liver of sulphur (sulphuret of potash) has been proposed as an expedient to free silver from copper: for if silver containing copper be fused with alkaline sulphuret, the base metal will combine with the latter, and be converted into scoriæ floating on the silver.

Keir's Mode of separating Silver from Copper.

120. A compound acid that will act exclusively upon silver, is made by dissolving one pound of nitrate of potash (common nitre or saltpetre), in eight or ten pounds of sulphuric acid (oil of vitriol), or by mixing together sulphuric and nitric acids. This acid dissolves silver easily, while it will not attack copper, iron, lead, gold, or platina.

These properties have rendered it capable of a very useful application in the arts. Among the manufactures at Birmingham, that of making vessels of silver, plated on copper, is a very considerable one; and the method of effecting the separation of silver and copper, by means of the abovementioned compound of sulphuric acid and nitre is now commonly practised by the manufacturers at Birmingham, and is much more economical, and much easier executed, than any method previously practised: nothing more is necessary than to put the pieces of plated metal into a glazed earthen pan, pour upon them some of the acid liquor, stir them about, that the surfaces may be frequently exposed to fresh liquor, and assist the action by a gentle heat, from 100° to 200° of FAHRENEIT's thermometer.

When the liquor is nearly saturated, the silver is precipitated from it by common salt, forming muriate of silver, or luna cornea, easily reducible to a metallic state, by melting it in a crucible, with a sufficient quantity of potash; and lastly, by refining the melted silver, if necessary, with a little nitre thrown upon it. In this manner the silver will be obtained sufficiently pure, and the copper will remain unchanged. Else the silver may be precipitated in its metallic state, by adding to the solution of silver a few of the pieces of copper, and a sufficient quantity of water to enable the liquor to act upon the copper.

A Method of obtaining Gold in a pure State.

121. Perfectly pure gold is obtained by dissolving the gold of commerce into nitro muriatic acid, and precipitating the metal, by adding a weak solution of sulphate of iron. The precipitate, after being well washed and dried, is pure gold.

A Method of obtaining Silver in a pure State.

122. Dissolve the silver of commerce in nitrc aci d, and add to it some muriatic acid; a white curdy precipitate, called muriate of silver, will be formed. To reduce this to the metallic state, mix one part of it with three of soder, expose the whole to a white heat, and when the mixture is well fused, suffer it to cool; then break the crucible, and separate the pure silver from the muriate of soder which has been formed.

A Method of obtaining pure Copper.

123. Dissolve the copper of commerce in muriatic acid, and precipitate it by a polished plate of iron; the precipitate will be pure copper.

To make Brass, and other alloys of Copper.

124. *Brass* is made by fusing together lapis calaminaris (which is an ore of zinc) and copper.

Tornbac is formed by melting together twelve parts of copper with three of zinc.

Gun-metal consists of nine parts of copper and of tin.

Bell-metal is copper alloyed with one-sixth of tin. A smaller proportion of tin is used in making church bells than clock bells, and a little zinc is added for the bells of repeating watches, and other small bells.

Cock-metal is made with copper alloyed with zinc and lead.

The *gold coins* of this country are composed of eleven parts of gold and one of copper.

Standard silver contains fifteen parts of silver and one of copper.

CHAPTER VI.

THE PHILOSOPHY OF THE VEGETABLE KINGDOM.

SECTION I.

INTRODUCTION.

125. VEGETABLES are organized productions supported by air and food, endowed with life, and subject to death, like animals. They have, in some instances, *spontaneous*, not voluntary motion. They are sensible to the supply of nourishment, the action of the air, and light, and thrive or languish, according to the wholesome application of these

stimulants. This is evident to all who have ever seen a plant growing in a situation, for which it is not suitable. Those who have gathered a *rose*, know how soon it withers; and the familiar application of its fate to that of human life and beauty, is not more striking to the imagination, than philosophically correct.

The history of the vegetable kingdom is termed BOTANY, a science which includes the practical discrimination, the methodical arrangement, and the systematic nomenclature of vegetables.

The external covering of plants, is commonly transparent and smooth; but sometimes it is downy; and sometimes so hard that flint has been detected in its composition. The Dutch rush serves as a file to polish wood, ivory, and even brass. Under the cuticle, is found the *cellular integument* of a pulpy texture, and the seat of colour. It is usually green in the leaves and stems, and is dependant for its hue on the action of light.

When the cellular integument is removed, the *bark* presents itself; in plants and branches only one year old, the bark consists of a simple layer. In the branches and stems of trees it consists of as many layers as they are years old. The Peruvian bark affords 'a cooling draught to the fevered lip;' that of the cinnamon yields a rich cordial; that which is stripped from the oak, is used for tanning. Immediately under the bark is situated the *wood*, which forms the great bulk of trees and shrubs. This also consists of numerous layers, as may be observed in the fir, and other trees; and from these concentric circles, the age of the tree is determined. Within the centre of the wood is the *medulla* or pith, a cellular substance, juicy when young, extending from the roots to the summits of the branches. In some plants, as in grasses, it is hollow, merely lining the stem. The trunk enlarges by the formation of new *liber*, or inner bark, every year, the undermost layer is transformed into *cortex* or outer bark, becoming the *laburnam* or soft wood of the next, and the laburnam becoming the *lignum* or hard wood.

The chemical or elementary principles of vegetables, are *carbon*, *water*, and *air*; or hydrogen (15), and oxygen (85), for the constituent parts of (100) *water;* and azote and nitrogen (72), and oxygen (28), as the constituent parts of (100) atmospheric *air ;* and *carbon.*

124. Vegetables generate, or give out oxygen or vital air, in the light or sunshine by a natural process of their own. The saccharine and oily productions of vegetables are parts of their sap or juices ; but the turpentine, bitter, and acid principles, are effects of secretion. The green colour of vegetables arises from the oil they contain ; the rays of the sun extract the oxygen from the outer surface, and leave the carbon and hydrogen the constituent parts of oil. Healthy vegetables, in general, perspire water by the under part of their leaves, equal to one-third of their weight, every twenty-four hours. Nor do they derive their substance in a principal degree from the matter of the soil in which they grow ; but they are created as it were by a vital principle of their own, out of air and water, and of the imperceptible matters combined with air and water, from which they derive distinctions of smell, taste, and substance.

SECTION II.

OF ROOTS, BUDS, TRUNKS, LEAVES, PROPS, INFLORESCENCE, FRUCTIFICATION, AND CLASSIFICATION.

125. ROOTS are necessary to fix and hold plants, in the earth from which they imbibe nourishment. Roots are either *annual* or living for one season, as in barley; *biennial*, which survive one winter, and after perfecting their seed, perish at the end of the following summer, as wheat; or *perennial*, which remain and produce blossoms for an indefinite number of years, as those of trees and shrubs in general. The root consists of two parts: The *caudex* or stump, which is the body or knot of the root, from which the trunk and branches ascend, and the fibrous roots branching from the *caudex.*

Each tree, each plant, from all its branching roots,
Amid the glebe small hollow fibres shoots;

Which drink with thirsty mouths the vital juice,
And to the limbs and leaves their food diffuse;
Peculiar pores peculiar juice receive;
To this deny, to that, admittance give.

BLACKMORE.

126. *Buds* are, in most instances, guarded by scales, and furnished with gum or woolliness, as an additional defence. Buds are various in their forms, but very uniform in the same species, or even genus. They unfold the embryo plant.

127. The *trunk* of a tree includes the stems or stalks. The stem as it advances in growth, either supports itself, or twines round other bodies. It is either *simple*, as in the lily: or *branched*, as in other plants.

128. *Leaves* are generally so formed as to present a large surface to the atmosphere. When of any other hue than green, they are said to be *coloured*. The internal surface of a leaf is vascular and pulpy, clothed with a cuticle, very various in different plants, but its pores are always so constructed, as to admit of the requisite evaporation or absorption of *moisture*, as well as to admit and give out air, and light also acts through this cuticle.

129. The effect of *moisture* must have been observed by every one. By absorption from the atmosphere, the leaves are refreshed; by evaporation, when separated from their stalks, they soon fade and wither. The nutritious juices, imbibed from the earth, become *sap*, and are carried by appropriate vessels into the substance of the leaves, and these juices are *returned* from each leaf into the bark.

This is effected by a double set of vessels, analogous to the arteries and veins in animals, and is the circulation of the vegetable blood or sap. The sap is carried into the leaves for the purpose of being acted upon by *air* and *light*, with the assistance of heat and moisture, and by all these agents, a most material change is wrought in the component parts of the sap, according to the nature of the secretions. The *green* colour of the leaves is owing to the action of light, but they are subject to a disease by which they become partially spotted or streaked, and in this state are variegated. The irritable nature of leaves is very extraordinary, for the sensitive plant, common in hot-houses, when touched by any extraneous body, folds up its leaves one after another, and the foot-stalks droop, as if dying.

130. *Props* or *falera,* are appendages to the true leaves, or to their stalks.

Your contemplation further yet pursue:
The wondrous world of vegetables view!
See various trees their various fruits produce,
Some for delightful taste, and some for use.
See sprouting plants enrich the plain and wood,
For physic some, and some design'd for food.
See fragrant flowers, with different colours dy'd,
On smiling meads unfold their gaudy pride.

BLACKMORE.

131. *Inflorescence* treats of the different kinds or modes of flowering. Sometimes the flowers surround the stem in a garland or ring, as in mint, dead-nettle, &c. In other plants, a cluster, which bears several flowers, each on its own stalk, like a bunch of currants. In other plants, numerous crouded flowers are ranged along an upright, common stalk, expanding progressively, as in wheat and barley. Again we find a flat topped spike, as in the cabbage and wall-flower.

———————— Who can paint
Like Nature? can imagination boast,
Amidst his gay creation, hues like hers?
And can he mix them with that matchless skill,
And lay them on so delicately fine,
And lose them in each other, as appears
In every bud that blows? If fancy, then,
Unequal fails beneath the pleasing task,
Ah! What shall language do?

THOMSON.

132. *Fructification* is a term comprehending not only the parts of the *fruit,* but those also of the flower. The parts of fructification are described by many technical words, but include chiefly the flower-cup, or external covering of the flower; the calyx, consisting in general of the coloured leaves of the

flower; the stamens, and the cells containing the pollen or fecundating dust: the pistils stand in the centre of the circles formed by the stamens, and consist of the germen or rudiments of the future fruit or seed; the seed are composed of the embryo or germ, and are often accompanied by accessory parts; as spines, hooks, scales, and crests, generally serving to attach such seeds as are furnished with them, to the rough coats of animals, and thus promote their dispersion.

> Go, mark the matchless workings of the Power
> That shuts within the seed the future flower;
> Bids these, in elegance of form excel,
> In colour these, and those delight the smell;
> Sends Nature forth, the daughter of the skies,
> To dance on earth, and charm all human eyes.
>
> COWPER.

133. *Classification,* though last in order is first in importance; and of all the systems of Botany, that of Linnæus, now generally acknowledged and adopted, is founded on the number, situation, and proportion of the *stamens* and *pistils,* whose uses and structure have been just explained. The following twenty-four classes owe their distinctions principally to the stamens.

SECTION III.

THE CLASSES.

1. *Monandria,* one stamen.
2. *Diandria,* two stamina.
3. *Triandria,* three
4. *Tetrandria,* four.
5. *Pentandria,* five.
6. *Hexandria,* six.
7. *Heptandria,* seven.
8. *Octandria,* eight.
9. *Enneandria,* nine.
10. *Decandria,* ten.
11. *Dodecandria,* Twelve.

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* To the mere English reader the trammels of scientific classification are the numerous Latin and Greek words, which by their signification express the thing for which they stand; bnt to those who are versed in those languages, the words borrowed from them are so many keys by which to unlock the stores of nature.

12. *Icosandria*, twenty or more stamina, inserted into the calyx.
13. *Polyandria*, all above twenty inserted into the receptacle.
14 *Didynamia*, four stamina, two long, and two short.
15. *Tetradynamia*, six stamina, four long, and two short.
16. *Monadelphia*, the stamina, united into one body by the filaments.
17. *Diadelphia*, the stamina united into the bodies by the filaments.
18 *Polyadelphia*, the stamina united into three or more bodies by the filaments.
19. *Syngynesia*, antlers united into a tube.
20 *Gynandria*, stamens inserted either upon the style or germen.
21. *Monoecia*, stamens and pistils in separate flowers, but on the same plant.
22. *Diecia*, stamens and pistils, like the former, in separate flowers, but on two separate plants.
23. *Polygamia*, stamens and pistils separate in some flowers, united in others, either in one, two, or three distinct plants.
24 *Cryptogamia*, stamens and pistils, either not well ascertained, or not to be numbered with certainty

135. The *orders*, or subdivisions of the classes are generally marked by the number of the pistils, or by some other circumstance equally intelligible. The names of these, as well as of the classes, are both of Greek derivation, and designate the functions of the respective organs. A further division of the orders, founded on distinctions in the nectarium, lead to *Genera*. Other divisions of the genera, in regard to the root, trunk, leaves, &c. lead to *Species*; and casual difference in *species* are called *varieties*.

The *orders* of the first thirteen classes are established upon the number of pistils, and they are designated by the Greek words monogynia, digynia, trigynia, &c. signifying one, two, three, &c.

We have in the canna or American reed an instance of the monandria monogynia, that is, a flower with one stamen and one pistil. In the jasmine we see an instance of the diandria monogynia, or flower that has two stamens and one pistil. In the linum or flax, there are five stamens and five pistils: and the flower is called pentandria pentagynia, that is, one having five males and five females, and so of the rest.

The orders of the fourteenth and fifteenth classes are characterized by the manner of producing seed; and those of the sixteenth, seventeenth, and eighteenth, are founded on the number of stamens which compose them.

The orders of the nineteenth class are marked by the united or separated, barren or fertile nature of the florets.

The orders of the twentieth, twenty-first, and twenty-second, are distinguished, almost entirely, by the number of their stamens.

The orders of the twenty-third are called monoecia, and dioecia, for reasons which have been given in the last lesson.

The four orders of the twenty-fourth class are ferns, mosses, flags, fungi, and liver worts.

The study of botany has been applied as a guide to estimate the qualities of plants.

The first order of the fourteenth class, denominated "didynamia gymnos permia," are all innocent or wholesome: those of the other order are febrile, narcotic, and dangerous, being allied to a large part of the pentandria monogynia, known to be poisonous, as containing henbane, nightshade, and tobacco. The whole class tetradynamia, is wholesome. Whenever the stamens are found to grow out of the calyx, they indicate the pulpy fruits of such plants to be wholesome, except the seeds of the laburnum, which, if eaten unripe, are violently emetic and dangerous. Milky plants are generally to be suspected. Umbelliferous plants which grow in dry or elevated situations, are aromatic, safe, and often wholesome, while those that inhabit low and watery places are among the most deadly poisons.

136. The natural substances found in all vegetables are, *sugar* in the sugar-cane, beet, carrots, &c.; *gum,* or mucilage, oozing from many trees; *jelly,* procured from many fruits; *turpentine* and *tar* from the pine; *bitters,* from hops and quassia; and the *narcotic* principle from the milk of *poppies,* lettuce, &c.

137. The vegetables of greatest value to man, produce *gluten* or *starch*; as wheat, potatoes, barley, beans, &c. *Oils* are produced by pressing the seeds or kernels of vegetables; as olives, almonds, linseed, &c. *Volatile oils* are distilled from peppermint, lavender, &c. *Wax* is collected from all flowers by bees. *Resins* exude like gum from firs and other

trees; and are known as balsams, varnishes, turpentine, tar, pitch, &c. Of this class too, is *Indian rubber*; which is a gum that exudes from a certain tree in South America. And *iron* also mixes with the substance of most vegetables; and is the cause of the beautiful colours of flowers. *Pot-ash* is obtained from the ashes of burnt vegetables; as kelp, vine, fern, &c.

Hail, Source of Being! Universal Soul
Of heaven and earth! Essential presence, hail!
By THEE, the various vegetative tribes,
Wrapt in a filmy net, and clad with leaves,
Draw the live ether, and imbibe the dew:
By THEE, disposed into congenial soils,
Stands each attractive plant, and sucks and swells
The juicy tide, a twining mass of tubes:
At THY command, the vernal sun awakes
The torpid sap, detruded to the root
By wintry winds; that now in fluent dance,
And lively fermentation, mounting, spreads
All this innumerous colour'd scene of things.

THOMSON.

Anatomy of Plants.

138. In order to comprehend this subject the following general principles may be of service; they may be verified in most plants; and observation is here the best teacher.

First, All plants do not perspire.

2. That there is not in all plants an uniform circulation of sap.

3. In general the spiral wire is the muscle of the plant.

4. The leaves are for the most part the lungs of the plant.

5. The different divisions of the leaves, are formed of the elongations of the bark and inner bark vessels.

6. Hairs and instruments of that kind are the means which Nature takes to form the different juices according to their various affinities. That these figures were taken for perspiration, but are

in reality liquids received from the atmosphere and flowing into the plant, not a juice running from it.

7. The root is the grand laboratory of all plants, where the great chemical operations are going on.

8. The heart of the seeds is formed in the extremities of the side-roots.

9. The flower is also formed in the middle root, and the pollen in the tap root.

10. The corolla of a flower is formed by bubbles of water placed in rows, and owes all its beauty, and the lightness of its tint, to the refraction and reflection of the sun on the drops of water which form its pabulum. This though of apparent subtilty is nevertheless verified by experiment.

11. The roots and leaves of a plant will most exactly mark not only what is the soil in which they originally grew, but the situation from which they came, whether a water plant or a dry plant, a rock or a valley plant, &c.

12. The water, semi-water, and rock plants alone can be said to have direct air-vessels, though these may be found in parasite and early spring plants, such as the crocus and hyacinth.

SECTION IV.

POPULAR BOTANY.

139. In order to illustrate the advantages of this entertaining science we will give a few specimens from the "Useful Knowledge" of that elegant writer on the Mineral, Vegetable, and Animal Kingdom, the Rev. Wm. Bingley. And first a common root, the parsnip shall furnish an example.

The wild and cultivated parsnips differ much from each other, but particularly in the roots of the latter being large and succulent, and those of the former being slender and woody. Parsnips are propagated by seed sown in February or March, and the roots are in perfection about October. These, besides their use as a vegetable for the table, are of great value for the feeding of cattle, horses, sheep, and hogs. Land in Guernsey, which lets for £7 an acre, is sown with parsnips to feed cattle; and the milk of the cows so fed is not only richer than it would otherwise be, but yields butter of fine saffron colour and excellent taste. If washed clean and sliced among bran, horses eagerly devour parsnips, and thrive well, though there is a notion that they are thereby subject to become blind. They fatten sheep and oxen in a short time; and for pigs they are at least equal if not superior to carrots. As food for mankind they are considered extremely nutritive; and may with great advantage be kept on board ships for long voyages. It is, however, said that they should not be dug up for use in the spring, because, at that season, the nutritive juices rising upward to produce the seed, they are then unwholesome. Parsnips abound in saccharine juice; and various experiments have in vain been made with a view to extract sugar from them. In some parts of Ireland they are used instead of malt in brewing; and, when properly fermented, afford an agreeable beverage. The *seeds* are said in some cases to have proved an efficacious remedy in intermittent fevers.

140. Let us read as a second example Mr. Bingley's description of the peach.

This rich and delicious fruit is highly and deservedly esteemed at table, as an article in our deserts; and, when ripe and fresh, is grateful and wholesome, seldom disagreeing with the stomach, unless this organ be not in an healthy state, or the fruit has been eaten to excess. When preserved in wine, brandy, or sugar, it looses its good properties. The *kernels* yield a salubrious bitter. The *flowers,* which are very beautiful, and appear only in the spring, emit an agreeable odour, have a bitterish taste, and, including the calyx as well as the corolla, are used for medical purposes. The leaves are occasionally employed in cookery, but they ought not to be used without great caution on account of their injurious properties.

There are many varieties of the peach, some of which are much more esteemed than others. The mode in which the trees are usually propagated is by a process termed budding, or grafting upon the stock of some other tree; and by this process those of any favorite kind may be exactly obtained.

141. We shall take as a third example a vegetable whose history is perhaps as engaging to the epicure as to the child.

The Truffle (*Tuber cibarium*) is a globular, solid, and warty fungus, without root, which grows at the depth of four or five inches beneath the surface of the earth, and is from the size of a pea to that of a potatoe.

This, one of the best of the edible funguses, is chiefly found in hilly woods and pastures, which have a sandy or clayey bottom; it occurs on the downs of Wiltshire, Hampshire, and Kent. Truffles are generally discovered by means of dogs, which are taught to hunt for them by their scent; and wherever they smell one of them they bark, and scratch it up. In Italy they are hunted in somewhat similar manner by pigs.

Truffles are either served at table roasted in a fresh state like potatoes, or they are cut into slices and dried, as an ingredient for sauces and soups. Those that are most delicious are internally of white colour, and have somewhat the odour of garlic.

In England truffles seldom exceed the weight of four or five ounces, whilst on the continent they are known to weigh fifteen or sixteen ounces each.

142. The commonest plants sometimes possess the most extraordinary properties: thus, the Buck-bean, or Bog-bean (*Menyanthes trifoliata*) is a very common plant in shallow ponds; and is distinguishable by its leaves growing in threes, and its pink and white flowers being shaggy on their inner surface.

There is no British plant the flowers of which are more beautiful than those of buck-bean: and nothing but the difficulty of propagating it in dry ground could prevent its having a place in every garden. The *leaves* are intensely bitter, and are occasionally used in the Highlands of Scotland as a tea, to strengthen the stomach. The inhabitants of some part of Sweden employ them in place of hops, to impart a bitter taste to ale; two ounces of them being considered equal in strength to a pound of hops. By some persons the leaves of buck-bean are smoked instead of tobacco; and different preparations of this plant have been found efficacious as a remedy against agues, and in scorbutic and scrophulous diseases, rheumatisms, and dropsy. There is an opinion that sheep, when compelled to eat of buck-bean are cured of the rot. In Lapland it is said that the pounded roots, though very unpalatable, are sometimes converted into bread.

143. And though the following be a subject of little comparative importance, the mode in which it is treated makes it peculiarly interesting to the descendants of ancient Britons. Leeks *(allium porrum)* belong to the onion or garlic tribe, and are known by their leaves growing out on each side, somewhat in the shape of a fan.

In some countries leeks are much esteemed for culinary uses, in soups, broths, and for boiling as greens with meat. They are considered the badge of the Welsh nation, and representations of them are frequently worn by persons of that country on the day of their patron saint, St. David. The origin of this custom was an occurrence, during the Welch wars, in which a party of Welchmen, wanting a mark of distinction, and shortly afterwards passing through a field or garden of leeks, seized and stuck them in their caps, and under this signal were victorious.

Leeks are natives of Switzerland.

We will close this subject with the following articles which may be considered

Botanical Phenomena.

144. In Ampthill Park, the residence of the late Lord Ossory, now that of Lord Holland, stands one of those magnificent monarchs of the wood,—a particularly large oak. The circumference of its base is upwards of forty feet; its middle girt is about thirty: it is quite hollow, forming a concavity sufficient to contain four or five middle-sized persons standing together withinside.

The chief of its branches, which is much greater in dimension than many parent oaks, is supported by a couple of large wooden props, on account of its weight being too great to be kept up by the main body of the tree.

It was the favourite of the late proprietor, Lord Ossory; and, in 1802, he caused a white board to be fixed on it, which still continues, and on which the following lines are inscribed:

Majestic tree, whose wrinkled form hath stood,
Age after age, the patriarch of the wood;
Thou, who hast seen a thousand springs unfold
Their ravel'd buds, and dip their flowers in gold;
Ten thousand times yon moon re-light her horn,
And that bright star of evening gild the morn!
  Gigantic oak! thy hoary head sublime,
Erewhile must perish in the wrecks of time:
Should round thy head inocuous lightnings shoot,
And no fierce whirlwinds shake thy stedfast root,
Yet shall thou fall; thy leafy tresses fade,
And those bare scatter'd antlers strew the glade;
Arm after arm shall leave the mouldering bust,
And thy firm fibres crumble into dust.
The Muse alone shall consecrate thy name,
And by her pow'rful art prolong thy fame;
Green shall thy leaves expand, thy branches play,
And bloom for ever in th' immortal lay.

145. There is a large oak in Saleey forest, Northamptonshire, which is forty-two feet in girth at the surface of the ground, and diminishes very little for several feet upwards.

It is short in proportion to its diameter. It is so completely excavated by the secret hand of all-destroying Time, that the trunk is a mere shell. There is a passage formed quite through it,—

Arch'd so high, that giants may jet through,
And keep their impious turbans on, without
Good-morrow to the sun.

The branches are short and stunted, and its whole appearance betrays those marks of general decay, which threaten its fall at no distant period. Some years ago it had two benches fixed in the inside, and which afforded accommodation sufficient for half a score people to sit very comfortably. The seats have disappeared; but care has been taken to enclose it with a rail-fence, to prevent cattle from disturbing it in the last days of its old age.

146. There is now growing in the Earl of Ilchester's park, at Melbury, in the county of Dorset, an oak-

tree that measures upwards of thirty feet in circumference, at about four feet distance from the ground. It was measured in 1817, when it appeared in full vigour, and most likely had not attained its full growth. This tree is called "*Billy Wilkins.*"

There is an oak-tree in the parish of Winfarthing, in Norfolk, on the estate of the Earl of Albemarle, which is larger than either of the foregoing. It measures, breast-high, at its smallest girth, thirty-five feet in circumference. It is a mere rind, and is as striking within as on the outside, and appears as if it would contain forty persons. One arm is living, and the bark covers about an eighth part of the body: the rest of the body is bare of bark, and appears a complete ruin, and most likely, will not long hold together.

Obs. The next article with which we will close this chapter shews, how long wood a vegetable product may in certain circumstances be preserved.

147. In the paper called the General Evening Post, for March the 17th, 1818, there is an account which has been lately received at the Admiralty, of an interesting discovery made in the south of Africa, about twenty miles north of Cape Town. Some persons, in digging, happened to strike upon what appeared a beam of timber; but, tracing it, they found a ship deeply imbedded in the soil.

A plank of it has accompanied the account of the discovery to the Admirality. Several other ships, at different times, and in different parts of the world, have been discovered beneath the surface of the earth.

It is recorded by Fulgosas, that in the year 1462, as some men were working a mine near Berne, in Switzerland, they found a ship 100 fathoms deep in the earth, with anchors of iron, and sails of linen, with the remains of forty men.

Pairre Naxis relates a like history of another such ship having been found under a very high mountain.

The Jesuit Eusebius Newcombergus, in his fifth book of Natural History, says, that near the port of Lima, in Peru, as the people were working a gold mine, they found a ship on which were many characters, very different from ours. Strabo also relates, in his first book, that the wrecks of ships have been found 375 miles from the sea.

148. Dr. Plott, in his Natural History of Staffordshire, relates a story, that the mast of a ship, with a pulley hanging to it, was found in one of the Greenland mountains. Is it to be supposed that those ships, which have been found beneath the surface of the earth, were antediluvian ships? If they were (and mankind knew the use of ships before the flood), it is not probable that all mankind, except Noah and his family, would have been drowned by a deluge of waters.

Is it not more probable, that violent earthquakes since the deluge have been the means of swallowing up these ships? but the sea must, at that time, have covered that part of the land where they have been found.

149. In the year 1746, Calloa, a sea-port town in Peru, was violently shaken by an earthquake, and of 5000 inhabitants only 200 were saved. The sea rolled in upon the town in mountainous waves; ships of burden were conveyed over the garrison walls; and one ship, which arrived from Chili the preceding day, was conveyed to the foot of the mountains, and left on dry ground.

On the 7th day of June, 1692, the town of Port Royal, in Jamaica, was in two minutes totally destroyed by an earthquake: many ships were also swallowed up.

150. The earthquake which visited Sicily in 1693, shook the whole island, and extended to Naples and Malta; the city of Catania was destroyed, with 18,000 inhabitants: fifty-four cities and towns, besides many villages, were either greatly injured or totally destroyed. The city of Catania was rebuilt, and is now again in ruins by the late earthquakes that shook all Sicily. And, on the first of November,

1755, Lisbon in Portugal was also destroyed by an earthquake: many ships in the harbour were also swallowed up, only their masts appearing above water: the sea suddenly rolled in like a mountain, ships were driven from their moorings, and tossed about with great violence. The same day that Lisbon was destroyed, Cadiz was violently shaken by an earthquake; and the inhabitants were yet more alarmed at the appearance of a wave coming towards the town at least sixty feet higher than common: it beat in the breast-work of the walls, and carried pieces of eight or ten tons weight forty or fifty yards from the wall, and passed over a parapet sixty feet above the ordinary level of the water.

St. Ubes, a sea-port town twenty miles south of Lisbon, was entirely swallowed up by the repeated shocks of this earthquake: in Africa, near Morocco, the earth opened and swallowed up a village with 8 or 10,000 inhabitants; Sallee and Tangiers also suffered greatly by an inundation of waters. The same earthquake was felt all over Spain: at Ayomonte, near where the Guadiana falls into the bay of Cadiz, the water came on in vast mountains, and laid under water all the coasts of the islands adjacent. The waters in many parts of Britain were greatly agitated at the same time. At three quarters after six in the evening, on the same day that Lisbon was sunk, and about the time of two hours' ebb of the tide, a great body of water rushed up in Glamorganshire in Wales, accompanied with great noise, and in such a quantity that it floated two vessels of 200 tons burden each.

At Kinsale, in Ireland, a great body of water rushed with such violence into the harbour, that it drove two vessels from their moorings.

In Holland, the agitations were more remarkable: at Alphen, on the Rhine, the waters were agitated to such a violent degree, that buoys were broken from their chains, large vessels snapped their cables, smaller ones were thrown out of the water, upon the land, and others lying on land were set afloat. This destructive earthquake extended over a tract of land of four millions of square miles.

151. History records a number of instances of great inundations of the sea on the land by earthquakes:

the bottom of the sea is first elevated by means of subterraneous fires before the elastic vapours can find a vent; and the sea, of consequence, must flow over the land, the depth in proportion to the elevation of the bottom of the sea.

The master of an American vessel in north latitude 25°, at the time of the great earthquake, saw, from his cabin window, land about a mile from his ship; but, coming upon deck, the land was no more to be seen; and he perceived a violent current cross the ship's lay to the leeward. In about a minute this current returned with great impetuosity; and, at a league distance, he saw three craggy rocks throwing up water of various colours resembling fire; the phenomenon in about two minutes ended in a black cloud, which ascended very heavily: after it had risen above the horizon no rocks were to be seen. No doubt, but many ships have been driven far inland, and swallowed up by the earthquakes that followed the inundations of the sea, some of which, in course of time, may be accidentally discovered.

CHAPTER VII.

OUTLINES OF ANIMATED NATURE.

SECTION I.

INTRODUCTION.

152. Several scientific and ingenious arrangements of the animal kingdom into classes, orders, genera, and species, have been successively adopted; that of Monsieur Cuvier, the French anatomist, possesses a high degree of merit. But though his arrangement evinces great anatomical precision, and the highest philosophical knowledge of animals, yet, to a general reader, it has a complicated and forbidding appearance, and is less attractive than the

more simple arrangement of Linnæus, which divides the animal kingdom into six classes; *mammalia, aves, amphibia, pisces, insecta, vermes,* or such as suckle their young; birds; creatures living equally on land, or in the water; fishes; insects; and worms. Each of these classes is subdivided into orders, genera, species, and varieties of those species.

> See thro' this air, this ocean, and this earth,
> All matter quick, and bursting into birth.
> Above, how high progressive life may go!
> Around how wide! how deep extend below!
> Vast chain of being! which from God began,
> Natures ethereal, human, angel, man,
> Beast, bird, fish, insect, what no eye can see,
> No glass can reach; from Infinite to thee,
> From thee to nothing.
>
> Pope.

These classes are thus arranged for conciseness,

	CLASSES.			
Body.	With vertebræ	Hot blood ——	Viviparous	I. Mammalia.
			Oviparous	II. Birds.
		Cold red blood..	With lungs......	III. Amphibia.
			With gills	IV. Fishes.
	Without vertebræ...	Cold white blood	Have antennæ ..	V. Insects.
			Have tentacula..	VI. Worms.

SECTION II.

THE CLASS MAMMALIA.

153. The class mammalia, consists of such animals as produce living offspring, and nourish their young with milk supplied from their own bodies; it comprises both the quadrupeds and whales.

Their head is the seat of the principal organs of sense, the mouth, the nose, the eyes, and ears.

154. *Touching* or *feeling*. The outside of the skin is covered with a thin pellicle, called the *epidermis,* cuticle, or scarf-skin. Under the cuticle, is the rete mucosum. In negroes, this substance is black, in Europeans, white, brown, or yellow. The *cutis vera,* or the skin, is a substance made up of fibres closely connected with each other, and running in

various directions, being composed of the extremities of numerous vessels and nerves. The *papillæ* of the fingers or inside of the hand, may become erect or elevated, and being gently pressed against a tangible body, receive an impression which is conveyed to the brain, and is called *touch.* Spiders, flies, and ants, have this sense in the greatest perfection.

155. *Tasting.* The tongue is covered with two membranes; the external is thick and rugged, especially in quadrupeds; the internal membrane is thin and soft, and upon it appear *papillæ,* or small elevations, like the tops of the small horns of snails. These papillæ are composed of the extremities of the nerves of the tongue, and piercing the external membrane, are constantly affected by those qualities in bodies, which have their tastes excited in the mind by means of these nervous papillæ, which are the immediate organ of tasting. This organ bears a strong analogy to the sense of touch.

156. *Hearing.* The undulations of the atmosphere, excited by the vibrations of sonorous bodies, are collected in the external ear and auditory passage, as in the hearing trumpet, and are conveyed to the *membrana tympani,* or drum, which they cause to vibrate. The effect is transmitted through the small bones, to the watery fluid that fills the internal ear, in which the delicate filaments of the auditory nerve float, and by this nerve the sensation is conveyed to the brain. But it is remarkable how nicely is the ear constructed in various animals; in man its position and form are admirably contrived for his erect posture; in quadrupeds we see it large, susceptible of easy motion, as when the horse lays his ears back or points them forward; in the mole it is lodged deep in the head.

The structure of the ear is also remarkable, for it is so contrived and tunnelled that it may not only catch sounds but prevent the more furious undulations of the air from injuring the interior membrane. And to prevent insects from lodging within its cavity, as well as to keep it moist and in tune, it is supplied with a bitter nauseous wax.

157. *Smelling.* The cavity of the nose is divided into two parts, called the *nostrils,* by a partition, of which the upper part is bony, and the lower cartilaginous. The upper part of the cavity is covered with a thick glandulous membrane, above which the *olfactory nerve* is finely branched out and spread over the membrane of the spongy bones of the nose, and other sinuous cavities of the nostrils. The odorous effluvia of bodies being disseminated in the atmosphere, the latter fluid passes through the nose in respiration, and the odorous par-

ticles are thus brought into contact with the fibres of the nerves, which, by their communication with the brain, excite in the mind the sense of smell.

158. *Seeing.* The eye is the organ of sight, and its sensations are of the utmost importance to the well-being and safety of animals. The eye is composed of three *coats*, covering one another, and inclosing different substances called *humours*. The three coats are the *sclerotica*, the *choroides*, and the *retina*. The three humours are the *aqueous*, the *crystalline*, and the *vitreous*. Objects are seen by means of their images being painted on the retina of the eye; in an inverted position, though they appear erect. When the crystalline humour loses its transparency the disorder is called a *cataract*, and the remedy applied is called *couching*, which is performed by thrusting a fine awl through the coats of the eye, and pushing the crystalline to the bottom of the eye, where it will remain, and its deficiency may be supplied with a convex lens. When the defect of vision is in the optic nerve it is called a *gutta serena*, and the disorder is generally incurable. The external parts of the eye, are the eye-brows, the eye-lids, and eye-lashes. The eye-brows defend the eyes from too strong a light, and serve to turn away substances which might otherwise fall into the eye. The eye-lids act as curtains, by covering and protecting the eyes during sleep: and in our waking hours they diffuse a fluid over the eye which renders it better adapted to transmit the rays of light. The eye-lashes guard the organ from danger, and protect it from dust and insects floating or flying in the atmosphere.

159. The mouth contains the teeth, which are inserted into two moveable bones, the upper and under jaw. The front or cutting teeth are in general wedge-shaped, and so placed that in action their sharp edges are brought into contact. Next to these are situated the canine teeth or tusks, which are in general longer than the front teeth, conical, and pointed. The teeth in the back of the jaw, and between which the food is chewed or masticated, are called grinders. In such animals as subsist on vegetable food the latter are somewhat flattened at the top, but in the carnivorous tribes their upper surfaces are furnished with sharp and conically pointed protuberances. It is principally from the numbers, form and disposition of the teeth that Linnæus has arranged the various genera or tribes of quadrupeds.

160. The class mammalia has been distributed into seven orders, founded for the most part on the number and arrangement of the teeth; and on the

form and construction of the feet, or of those parts in the seals (23), maniti (22), and whales, which supply the place of feet.

Orders of Mammalia.

I. Primates have the upper front teeth generally four in number, wedge-shaped, and parallel; and two teats situated on the breast, as apes and monkeys.

II. Bruta have no front teeth in either jaw; and the feet armed with strong hoof-like nails, as the elephant.

III. Feræ have in general six front teeth in each jaw; a single canine tooth on each side in both jaws; and the grinders with conic projections, as the dogs and cats.

IV. Glires have two long projecting front teeth in each jaw, which stand close together; and no canine teeth in either jaw, as the rats and mice.

V. Pecora have no front teeth in the upper jaw; six or eight in the lower jaw, situated at a considerable distance from the grinders; and the feet with hoofs, as the cattle and sheep.

VI. Belluæ have blunt wedge-shaped front teeth in both jaws; and the feet with hoofs, as the horses.

VII. Cetæ have spiracles, or breathing holes on the head; fins instead of fore feet; and a tail flattened horizontally, instead of hind feet. This order consists of the narwals, wales, cachalots, and dolphins.

SECTION III.

MAN.

161. The varieties of the human species as arranged by Blumenbach, are five in number.

1. *Caucasian* variety, which includes the Europeans, (excepting the Laplanders, and the rest of the Finnish race) the western Asiatics, as far as the river Ob, the Caspian sea, and the Ganges, and the northern Africans.

2. *Mongolian* variety, which includes the rest of the Asiatics, (excepting the Malays;) the Finnish races of the colder parts of Europe, as the Laplanders, &c. and the tribes of Esquimaux; extending over the northern parts of America from Bhering's Strait to the extremity of Greenland.

3. *Ethiopian* variety, contains the remaining Africans, besides those classed in the first variety.

4. *American* variety. To this belong all the Americans, except the Esquimaux.

5. *Malay* variety, includes the inhabitants of Malacca, of the South Sea, Ladrone, Philippine, Molucca, and Sunda islands.

Each variety is distinguished by the colour of the hair, and some striking peculiarities of feature. We shall now briefly describe the external and internal structure of the human body, and the five senses.

External Structure of the Human Body.

162. Among all the visible parts of the body, the head holds the most distinguished place; both because of its beauty, and because it contains the principles of sense and motion.

All the sentiments and passions of the soul are painted on the face, which is the most beautiful part of man; and where the principal organs of sense are found, through the medium of which we receive impressions from external objects. The different motions of the lips, and those of the tongue, whether it touch the palate or the teeth, serve for the articulation of words, and the different inflexions of sound. By the teeth, we can cut, or grind our food; and the saliva, so necessary to digestion, is furnished by a great number of glands, which are contained in the mouth. The head is placed upon the neck, and turns as on a pivot, to any side we please.

After the neck, comes the shoulders, so formed, that they are able to bear heavy loads. To the shoulders the arms are joined; and to those, the hands, which are so constructed as to perform an infinity of motions: to touch, take, raise up, draw back, repel, &c. the joints and bones serving to support and facilitate these motions.

The breast includes and defends the heart and the lungs; and for this purpose, it is composed of strong and hard ribs and bones. The diaphragm separates the breast and belly, which contains the stomach, liver, spleen, and intestines. All this mass rests upon the hips thighs, and legs, which like the arms, have different articulations, favourable to motion and rest. The feet sustain the whole, and the toes also contribute to it, because they serve to fix the feet more firmly upon the ground. The skin and flesh cover the whole body.

The hair and the down, which are found in different parts, protect them from the injurious effects of cold.

The *bones*, the most compact and solid parts of the body, serve for the attachment and support of all other parts. Bones are firm, hard, and perfectly insensible, they are divided into the long, the cylindrical, and the flat. There are 248 separate bones in the human body, these connected with wires, are sometimes made up into an artificial skeleton. There are eight separate bones in the skull that serve as a vault for the brain.

The vertebræ of the neck, so called from the ease with which they move, are separated from one another by an elastic substance. They support the head, which by their means is readily moved up and down, and turned round on either side as far as is necessary, like a piece of mechanism in a ball and socket; to the *breast bone*, the seven true, and five false ribs are fastened: the *spine* extends from the skull to the end of the loins and serves to lodge and defend the spinal marrow: the *pelvis* supports the abdomen, and the *thorax* reaches from the neck to the end of the breast bone, serving as a chest or place of safety for the heart, lungs, &c.

The Muscles, Arteries, Veins, and Circulation of the Blood.

163. The muscles constituting the flesh are susceptible of contraction and relaxation, and with the help of the tendons, are the instruments of animal motion.

The muscles are either *voluntary* or *involuntary*. The motions of the former are subject to the will, as in the case of the arms, legs, &c.

The heart, which is a hollow muscle, and the stomach, intestines, &c. act upon their contents by means of muscular fibres, called involuntary muscles, because their motions depend not on the will.

Each large muscle consists of two parts, viz. the belly, which is the active part, and its cord-like extremities called tendons which fasten the muscle to the bones, and perform their action by contracting both ends towards the centre.

The red colour which distinguishes the muscular parts of animals is owing to the number of blood-vessels dispersed through their substance.

164. The nerves, long, white, medullary cords, originate in the brain and spinal marrow, and serve for sensation. *Sensibility*, therefore, depends on the nerves: *motion* on the muscles.

The nerves conduce to all the enjoyments and sufferings of life, and to the intellectual faculties of man: the muscles are the chief support of animal life, and the source of all the bodily powers.

The heart is the principal organ of life; it contains four cavities for receiving the blood, and giving it a fresh impulse through the arteries.

165. The arteries originate in the heart, and through them the blood is carried from the heart to every part of the body, for the preservation of life, generation of heat, nutrition, and the secretion of the different fluids.

The pulse; felt at the wrist, temples, and various parts of the body, is occasioned by the reciprocal action of the heart and arteries, when the blood is driven from the heart into the arteries to be distributed through the whole body. The arteries terminate in small microscopic veins, which bring back the blood from the extremities to the heart.

166. The veins originate at the extremities of the arteries: they continually increase in size as they approach the heart: they do not pulsate, but the blood they receive from the arteries, they carry back with a slow motion, and it is prevented from returning by innumerable valves.

The double circulation of the blood is this: *one* motion is from the heart to the lungs, for the purpose of receiving oxygen from the air: the other motion is over all the parts of the body, to give out its nutritive and vital properties to the whole machine.

The Brain and Nerves.

167. The brain, a small pulpy mass of a whitish colour, occupies all that cavity formed by the bones of the skull.

The spinal marrow, a continuation of the brain, passes out of an opening in the skull, and runs down the canal of the back-bone, giving out nerves in its passage. The nerves run out in pairs, separate and spread over the whole body. The brain and nerves constitute entire the organs of feeling and sensation, the other parts of the body being incapable of feeling.

Excitement to action, produced by the will, proceeds from the brain and spinal marrow, through the medium of the nerves.

The nerves are therefore the organs; the brain, the receptacle of all our sensations and the source of all our ideas.

The Stomach, Liver, Digestion, &c.

168. The stomach, shaped like a bag, is the grand receptacle for the food, where it is retained until it is changed by *digestion.*

The stomach has two openings, *one* called the œsophagus, through which the food passes into it; the *other* intended to carry away the digested substance is called the intestinal canal.

The chief agent in digestion is the *gastric juice;* by the muscular nature of the stomach, the food when properly digested is propelled through the intestinal canal into the intestine, a membranous tube, about five times the length of the person in which it is contained.

Food is called *chyme,* in which state it enters the intestine, where it undergoes another change, and the *chyle,* a milk-like substance is separated from it. Chyle, is that substance from which the blood is formed, it is absorbed by the mouths of the lacteal vessels, every where distributed in intestines, while the feculent parts of the chyme and the bile are driven into the large intestine, by which it is expelled from the body.

169. The liver is formed for the secretion or separation of the bile from the blood, which passes into the *ductus hepaticus,* and thence into the gall-bladder, where it is kept till it is wanted to mix in the intestine.

The chief uses of the bile are, to extricate the chyle from the chyme; and to excite the peristaltic motion of the bowels.

The lacteals convey the chyle from the intestine into the jugular vein, that empties itself into the heart.

The kidneys are two glandular substances which drain the system of its redundant water; for this purpose a considerable portion of the blood is perpetually passing into each kidney, where it leaves its superfluous water, and then returns into the circulation by means of a particular vein.

The water thus strained from the blood is carried by canals, into the bladder, into which it passes through its two coats, which answer the purpose of a valve, to prevent regurgitation.

SECTION IV.

OF BIRDS

170. THE skeleton or bony frame of birds is lighter than that of quadrupeds, and is calculated for the power of flight; the spine is immoveable, the neck lengthened and flexible: the breast-bone very large, with a prominent keel down the middle, and formed for the attachment of strong muscles.

The bones of the wings are analogous to those of the fore legs in quadrupeds, but the termination is in three joints of which the exterior one is very short. The *legs* are analogous to the hind legs in quadrupeds, and terminate in general, in four toes, three of which are commonly directed forwards, and one backwards; in some birds there are only two toes, in some, only three. All the bones in birds are much lighter than in quadrupeds.

But who the various nations can declare
That plough with busy wing the peopled air?
These, cleave the crumbling bark for insect-food;
Those, dip the crooked beak in kindred blood;
Some, haunt the rushy moor, the lonely woods;
Some, bathe their silver plumage in the floods;
Some, fly to man, his household-gods implore,
And gather round his hospitable door,
Wait the known call, and find protection there
From all the lesser tyrants of the air.
The tawny eagle seats his callow brood
High on the cliff, and feasts his young with blood.

BARBAULD.

The *feathers* with which birds are covered, resemble the hair of quadrupeds, being composed of a similar substance in a different form. Beneath the general plumage, the skin in birds, is covered with a much finer feathery substance, called *down*. The *throat* after passing down to a certain distance, dilates into a large bag, answering to the stomach in quadrupeds: it is called the *crop*, and its great use is to soften and prepare the food taken into it, for passing into another receptacle, called the *gizzard*. This powerful stomach consists of two strong muscles, lined and covered with a strong coat furrowed on the inside. In the birds of prey or *accipitres*, this is wanting, the stomach being allied to that of quadrupeds. In this receptacle, the food is ground and reduced to a pulp. The *lungs* of birds differ from those of quadrupeds in not being loose in the breast, but fixed to the bones, they consist of a pair of large spongy bodies, covered with a membrane, which is pierced in several places, and communicates with large air-bags, dispersed about the cavities of the body.

The *eyes* of birds are more or less convex in the different tribes; and in general their sight is more acute than that of most other animals. Their ear though internal is constructed very nicely on the same general plan as in quadrupeds.

Their organs of motion are two *wings* and two *legs*; and they are destitute of external ears, lips, and many other parts which are important to quadrupeds.

171. Birds are produced from *eggs* which vary in number, size, and colour, but are always covered with a hard shell, and for the most part deposited in an artificial nest, and hatched by the genial warmth of the parent sitting upon them.

It wins my admiration
To view the structure of that little work—
A bird's nest. Mark it well within, without;
No tool had he that wrought; no knife to cut;
No nail to fix; no bodkin to insert;
No glue to join: his little beak was all;—
And yet how neatly finished! What nice hand,
With every implement and means of art,
And twenty years' apprenticeship to boot,
Could make me such another? Fondly, then,
We boast of excellence, whose noblest skill
Instinctive genius foils.

HURDIS.

Of Animated Nature.

172. Linnæus has divided this class into six orders. 1. Accipitres: 2. Picæ: 3. Passeres: 4. Gallinæ: 5. Grallæ: 6. Anseres.

The Orders of Birds are these:

1. *Land Birds.*

I. Rapacious birds have the upper mandible hooked, and an angular projection on each side near the point, as the eagles, hawks, and owls.

II. Pies have their bills sharp at the edge, somewhat compressed at the sides, and convex on the top, as the crows.

III. Passerine birds have the bill conical and pointed, and the nostrils oval, open, and naked, as the sparrow and linnet.

IV. Gallinaceous birds have the upper mandible arched, and covering the lower one at the edge, and the nostrils arched over with a cartilaginous membrance, as the common poultry.

2. *Water Birds.*

V. Waders have a roundish bill, a fleshy tongue, and the legs naked above the knees, as the herons, plovers, and snipes.

VI. Swimmers have their bills broad at the top, and covered with a soft skin: and the feet webbed, as the ducks and geese.

CHAPTER VIII.

OUTLINES OF ANIMATED NATURE, CONTINUED.

SECTION I.

AMPHIBIOUS ANIMALS.

173. This class includes all animals that live with equal facility on land or in water, and some others which do not exactly conform to this description. The amphibia from the structure of their organs, and the power they possess of suspending respiration at pleasure, support uninjured, a change of element, and endure a very long abstinence. The *lungs* differ in appearance from those of other animals.

174 Numbers of amphibia possess a high degree of productive power, and will be furnished with new feet, tails, &c. when by any accident, those parts have been destroyed. Their bodies are sometimes defended by a hard, horny shield or covering: sometimes by a coriaceous or leathery integument: sometimes by scales, sometimes they have no par-

ticular coating. The amphibia, in general, are tenacious of life, and continue to move and exert many of the animal functions, when deprived of the head itself. By far the greater part are *oviparous*, some excluding eggs, covered with a hard or calcareous shell, like those of birds; others, such as are covered only with a tough skin, resembling parchment: and in many, they are perfectly gelatinous, without any kind of external covering, as in the spawn of a frog.

175. The amphibia are divided into REPTILIA, containing the amphibia pedata, or footed amphibia; and the serpentes, or footless amphibia.

In the REPTILIA, there are four genera: 1. *Testudo*, tortoise, turtle. 2. *Rana*, frog, toad. 3. *Draco*, dragon, or flying lizard. 4. *Lacerta*, lizards, crocodile, chamælon, newt, salamander, iguana.

Reptiles are characterized by breathing through their mouths; and by having feet, and flat naked ears; of this order are frogs, lizards, and tortoises.

Serpents are distinguished as being without feet, but frequently armed with a deadly poison, contained in fangs resembling teeth. In cold and temperate climates they conceal themselves in winter in cavities beneath the surface of the ground where they become torpid.

Some serpents are viviparous, as the rattlesnake, the viper, &c.; but those which are innoxious are oviparous, depositing their eggs in a kind of chain in a warm situation, where they are afterwards hatched.

The broad laminæ on the bellies of serpents are termed scuta, and the smaller, or divided ones beneath the tail are called scales, and from these the genera are characterized.

SECTION II.

OF FISHES.

176. Like the amphibious animals, the heart of fishes is unilocular, or consist but of one cavity, and their blood is less warm than that of quadrupeds and birds.

Gills, the organs of breathing in fishes, consist of a vast number of blood-vessels. The generality of fishes are covered with scales, analogous to the hair of quadrupeds, and the feathers of birds.

The *fins*, the chief instruments of motion, consist of a certain number of elastic rays of processes, either of one single piece, in the form of a spine, or of jointed pieces. The strong or spiny rays are placed at the fore part of the fin, and the soft or jointed rays towards the back part. By the various flexures of these organs, the movements of fishes are conducted; the perpendicular fins, situated on the back or upper part of the animal, keeping the body in equilibrio, while the *tail* operates as a *rudder* at the stern of a vessel, and the side or breast-fins as *oars*. The stomach is large, the intestines far shorter than in quadrupeds and birds: and the liver is very large, usually placed on the left side.

The *air-bladder*, or swimming bladder, is a very highly curious and important organ, lying closely beneath the backbone, and provided with a very strong muscular coat, which gives it the power of contracting at the pleasure of the fish, so as to condense the air, with which it is filled, and thus enable the animal to *descend* to any depth, and again to *ascend* by being restored to its largest size. Some fishes are destitute of the air-bladder, yet remain always at the bottom; as the whole tribe of flat-fish. The *teeth* are, in some tribes, large and strong, in others, very small,; in some, sharp; in others obtuse; in some, numerous; and in others, few. Sometimes they are placed in the jaws; sometimes in the palate or tongue; or, even at the entrance of the stomach. The *eyes* are, in general, large, flattened, or less convex than in quadrupeds and birds. In return, the central part of the eye, or what is called the crystalline humour, is of a globular shape, to give the animal the necessary power of vision, and to compensate for the comparative flatnés of the cornea.

The organ of *smelling*, in fishes, is large; and they have the power of contracting or dilating it at pleasure. This sense is extremely acute. The organ of *hearing* differs, in some particulars, from that in other animals, and is modified according to the nature of the fish. They are entirely destitute of *voice*. The particular kind of sound or chirp, which some tribes are observed to make, on being first taken out of the water, is entirely owing to the sudden expulsion of air from their internal cavities. The greater number of fishes are *oviparous*, producing soft eggs, usually known by the name of spawn. There have been 200,000 ova or eggs found in a *carp*; in a *perch*, weighing one pound two ounces, 69,216; in a carp of eighteen inches, 342,144; in a sturgeon of one hundred and sixty pounds, there was the enormous number of 1,467,500!!! The age of fish is determinable by the nũmber of concentric circles of the vertebræ or joints of the back-bone. In the Linnæan arrangement of fishes, the under or belly-fins, are termed *ventral,* and are considered analogous to the feet in quadrupeds; and it is from the presence or absence of the fins, that the divisions are instituted.

Far as creation's ample range extends,
The scale of sensual, mental powers, ascends:
Mark, how it mounts to man's imperial race,
From the green myriads in the peopled grass:
What modes of sight betwixt each wide extreme
The mole's dim curtain, and the lynx's beam:
Of smell, the headlong lioness between,
And hound sagacious, on the tainted green:
Of hearing, from the life that fills the flood,
To that which warbles thro' the vernal wood!
The spider's touch, how exquisitively fine!
Feels at each thread, and lives along the line:
In the nice bee, what sense so subtly true!
From poisonous herbs extracts the healing dew:
How instinct varies in the groveling swine,
Compar'd, half-reasoning elephant, with thine!
'Twixt that, and Reason, what a nice barrier!
For ever separate,—yet for ever near!

177. The fishes are divided into six orders, namely; 1. Apodes: 2. Jujulares: 3. Thoracici: 4. Abdominales: 5. Branchiostegi: 6. Chondropterygii.

I. Apodal fish have bony gills; and no ventral fins, as the *eel.*

II. Jugular fish have bony gills; and the ventral fins situated directly under the pectoral fins, as the *cod, haddock,* and *whiting.*

III. Thoracic fish have bony gills; and the ventral fins situated directly under the pectoral fins, as the *perch* and *mackerel.*

IV. Abdominal fish have bony gills; and the ventral fins on the belly behind the pectoral fins, as the *salmon, herrings,* and *carp.*

V. Branchiostegeous fish have their gills destitute of bony rays, as the sucker.

VI. Chrondropterygeous fish have cartilaginous fins as the *sturgeons, sharks,* and *skate.*

SECTION III.

THE INSECT CLASS.

178. Insects are distinguished from other animals by their being furnished with never fewer than six feet; and sometimes with many more; by their breathing, by spiricles or breathing-holes, situated at certain distances along each side of the body; and lastly, by the head being furnished with a pair of *antennæ,* or jointed horns, which are extremely various in the different tribes.

The first state in which the generality of insects appear, is that of an *egg*. From this is hatched the animal in its second state, when it is improperly called the *caterpillar*. The insect, in this state, is the *larva* or larve, a mask or disguise of the animal in its future form. The larve differs in its appearance, according to the tribe to which it belongs. When the time arrives for the larve to change into its next state of *chrysalis,* or *pupa*, it ceases to feed, and having placed itself in some quiet situation, for the purpose, lies still for several hours; and then by a laborious effort, frequently repeated, divests itself of its external skin, or larve-coat, and immediately appears in the very different form of a pupa. The Linnæan term *pupa* was given, from the indistinct resemblance which many insects bear in this state to a doll, or a child when swathed up, according to the old fashion. The pupa emerges at length the complete insect, in its perfect or ultimate form, from which it never can after change, nor can it receive any further increase of growth. This last or perfect state is termed the *imago.*

Thick, in yon stream of light, a thousand ways,
Upward, and downward, thwarting, and convolv'd,
The quivering nations sport; till, tempest-wing'd,
Fierce Winter sweeps them from the face of day;
E'en so, luxurious man, unheeding pass
An idle summer-life in fortune's shines;
A season's glitter! Thus they flutter on
From toy to toy, from vanity to vice:—
Till blown away by death, oblivion comes
Behind, and strikes them from the Book of Life.

THOMSON.

179. Some insects undergo a change of shape, but are hatched complete, in all their parts from the egg, and only cast

their skin from time to time, during their growth, till they acquire the full size of their species. The *mouth* in some tribes is formed for gnawing the food, and operates by a pair of strong horny jaws, moving laterally as in the beetle tribe; while in others, it is formed for suction, and consists of a sort of tube. In the butterfly, and moth tribe, it consists of a double tube, which, when at rest, is rolled into a spiral form, and when in use, extended at full length. The *eyes* differ in the different tribes, the greater number of insects are furnished with eyes apparently two in number, and situated on each side the head. The outward surface of the coats of these eyes may be compared to so many convex lenses or glasses. The head of the common dragon-fly, is furnished with 25,000 of these lenses! In *spiders*, the eyes are from six to eight in number; of a simple structure, and placed at a considerable distance from each other.

Observe the insect-race—ordain'd to keep
The lazy sabbath of a half-year's sleep!
Entomb'd beneath the filmy web they lie,
And wait the influence of a kinder sky;
When vernal sun-beams pierce their dark retreat,
The heaving tomb distends with vital heat—
The full-form'd brood impatient of their cell,
Start from their trance, and burst their silken shell!
Trembling awhile they stand, and scarcely dare
To launch at once upon the untry'd air—
At length assur'd they catch the fav'ring gale,
And leave their sordid spoils, and high in ether sail!
Lo! the bright train, their radiant wings unfold
With silver fring'd, and freckled o'er with gold;
On the gay bosom of some fragrant flow'r
They idly fluttering live their little hour,
Their life all pleasure, and their task all play,
All spring their age, and sunshine all their day!
Not so the Child of Sorrow—Wretched Man—
His course with toils concludes—with pain began
That high his destiny he might discern
And in Misfortune's school this lesson learn—
Pleasure's the portion of the inferior kind,
But Glory—Virtue—Heaven for *Man* design'd!

BARBAULD.

180. The *muscles*, or organs constituting the several portions of the flesh in insects, are more numerous than in the larger animals, and extremely irritable. In the human body, the muscles scarcely exceed 500, in a large caterpillar more than 4000 have been discovered! The power of the muscles is also much greater than in animals. A flea is capable of

springing at least 200 times its own length; whereas the jerbo and kangaroo in their most powerful springs, fall very short of the same *proportional* distance.

Wak'd by his warmer ray, the reptile young
Come wing'd abroad; by the light air upborne,
Lighter, and full of soul. From every chink,
And secret corner, where they slept away
The wintry storms; or rising from their tombs,
To higher life; by myriads, forth at once,
Swarming, they pour; of all the varied hues,
Their beauty-beaming parent can disclose.
Ten thousand forms, ten thousand different tribes
People the blaze! To sunny waters some,
By fatal instinct fly; where on the pool,
They, sportive, wheel; or sailing down the stream,
Are snatch'd immediate by the quick-ey'd trout
Or darting salmon. Through the green-wood glade
Some love to stray; there lodg'd, amus'd, and fed,
In the fresh leaf. Luxurious, others make
The meads their choice, and visit every flower,
And every latent herb; for the sweet task,
To propagate their kinds, and where to wrap,
In what soft beds, their young, yet undisclos'd,
Employs their tender care. Some, to the house,
The fold, and dairy, hungry, bend their flight;
Sip round the pail, or taste the curdling cheese.
Oft, inadvertent, from the milky stream
They meet their fate; or, weltering in the bowl,
With powerless wings, around them wrapt, expire.

THOMSON.

181. The orders of insects are, 1. Coleoptera: 2. Hemiptera: 3. Lepidoptera: 4. Neuroptera: 5. Hymenoptera: 6. Diptera: 7. Aptera.

I. Coleopterous insects have elytra or crustaceous cases covering the wings; and which, when closed form a longitudinal division along the middle of the back, as in the *chaffer*.

II. Hemipterous insects have four wings, the upper ones partly crustaceous, and partly membranaceous; not divided straight down the middle of the back, but crossed, or incumbent on each other, as in the *cock-roach*.

III. Lepidopterous insects have four wings covered with fine scales almost like powder, as in the *butterflies* and *moths*.

IV. Neuropterous insects have four membranous and semi-transparent wings veined like net-work; and the tail without a sting, as in the *dragon-fly* and *ephemera*.

V. Hymenopterous insects have four membranaceous and semi-transparent wings veined like net-work; and the tail armed with a sting, as in the *wasp* and *bee.*

VI. Dipterous insects have only two wings, as the *common house-flies.*

VII. Apterous insects have no wings, as the *spiders.*

Full nature swarms with life: one wondrous mass
Of animals, or atoms organized,
Waiting the vital breath, when Parent-Heaven
Shall bid his Spirit blow. The hoary fen,
In putrid streams emits the living shoals
Of pestilence.' Thro' subterraneous cells,
Where scorching sunbeams scarce can find a way,
Earth, animated, heaves. The flowery leaf
Wants not its soft inhabitants. Secure,
Within its winding citadel, the stone
Holds multitudes. But chief, the forest boughs,
That dance unnumber'd to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameless nations feed
Of evanescent insects. Where the pool
Stands, mantled o'er with green, invisible,
Amid the floating verdure, millions stray.

THOMSON.

SECTION IV.

THE CLASS VERMES, INCLUDING CONCHOLOGY..

182. THE *sixth* class in the Linnean system, denominated "vermes" includes not only worms, but those animals which have the general character of being slow in motion, of a soft substance, extremely tenacious of life, capable of re-producing such parts of their bodies as may have been taken away or destroyed, and inhabiting moist places.

This class is divided into five orders, and they are principally distinguished by their tentacula or feelers. They are generally considered as the lowest scale of animated nature.

Most of the animals in this class are imperfect when compared to quadrupeds, possessing neither eyes, ears, head, nor feet. Many of them, as the corals and corallines, approach to the vegetable tribe, and some of them resemble, at least in their coverings, productions in the mineral kingdom.

183. The first order of the class vermes is denominated "intestina," of which some of the individuals live within other animals; some in the waters, and a few in the earth. The "ascarides" inhabit the intestines of the human body; the "gordius" perforates clay to give a passage to springs, and the "lumbricus" or earth-worm, perforates the common soil, which it renders fit to receive rain. It is the food of moles, hedgehogs, and various birds.

184. And nothing can be more instructive than the study of this part of natural history, as may be shewn by a scientific description of the medicinal leach (*hirudo medicinalis*) a worm-shaped animal of olive black colour, with six yellowish lines on the upper part of the body, and spotted with yellow beneath. When fully extended the leech is generally two or three inches in length. It is found in stagnant and muddy waters. Bingley observes that,

The use of the leech is in medicine, to diminish the accumulation of blood in any particular part of the body. This they do by fixing themselves to the spot, forming a hole with three sharp teeth which are situated triangularly in their mouth, and sucking the blood through the wound. When they have drawn sufficient, they are easily loosened by putting upon them a small quantity of salt, pepper, or vinegar.

Leeches are caught in various ways, but one of the best is to throw bundles of weeds into the water which they inhabit. These if taken out a few hours afterwards will generally be found to contain a considerable number. They are collected from several of the rivers in the south of England, and are kept for sale, sometimes many thousands together, in casks or tubs of spring water. This is frequently changed, and all the slime and filth which exude from their bodies is carefully washed away.

It is said that if leeches be kept in a glass vessel, they will indicate a change of weather, by becoming at such times peculiarly restless and active.

185. The second order is denominated "molusca:" the animals of this order are naked, furnished with tentacula, or arms, of which the limax or slug is a good illustration.

The animals of the molusca order are exceedingly numerous: many of them are inhabitants of the sea, and serve as food to thousands of the more useful and important species of fish. Some of them emit a phosphorescent light, like the glow worm, and with other living insects, give a beautiful brilliancy to the sea. The star-fish are of this order.

The cuttle-fish, also of this order, possess the power of expelling a black fluid in considerable quantities, so as to discolour the water, to favour their escape when pressed hard by an enemy. This liquor was used as ink by the ancients; and is said to be the basis of modern Indian or Chinese ink. The bone in the back is converted into powder, and is used as pounce for paper, and as an excellent cleanser and preservative for the teeth.

186. The third order, called *molusca testacea*, or soft-bodied animals furnished with shells, is divided into three assortments, called univalves, bivalves, and multivalves; signifying that the shelly cover consists either of one, two, or several parts or valves.

A *univalve* shell may be exemplified by that of the common *snail;* the shell of which is simple or undivided. The substance of the shells of this order of animals, when chemically examined, is found to be a mild calcareous earth, deposited in a mass of net-work composed of animal matter. Every part is secreted by the animal itself; the whole surface of the animal being concerned in the formation of the shell. The shining matter left in the tracks of snails is that very substance, which when deposited in strata one above another, hardens by exposure to the air, and forms a shell. A *bivalve* shell may be exemplified by a *muscle*, in which the shell is composed of two pieces or valves; and lastly, a *multivalve* shell may be exemplified by any species of lepas or *bernacle*, in which the shelly covering of the animal is formed of several divisions. The shell animals are produced from eggs, in some species gelatinous or gluey; in others, covered with a hard or calcareous shell: and the young animal emerges from the egg with its shell on its back. The most familiar and convincing proof of this may be obtained by observing the evolution or hatching of the eggs of the common garden-snail, as well as of several water-snails, which deposit eggs so transparent, that the motions of the young, with the shell on its back, may be distinctly seen, some days before the period of hatching.

187. The edible snail (*helix pomatia*) is a shell animal distinguished by its large size, and nearly globular shape; being of brownish white colour, with

usually three reddish horizontal bands somewhat striated longitudinally; and having a large and rounded aperture with a thickened and reflected margin.

188. It is sometimes more than two inches in diameter; and is found in woods and hedges in several parts of Europe, and occurs in some of those in the southern counties of England.

By the Romans, says Bingley, towards the close of the republic, when the luxury of the table was carried to the greatest height of absurdity and extravagance, this species of snails were fattened as food in a kind of stews constructed for the purpose, and were sometimes purchased at enormous prices. The places for feeding them were usually formed under rocks or eminences; and if these were not otherwise sufficiently moist, water was conveyed to them through pipes bored full of holes like those of a watering pot. They were fattened with bran and the sodden lees of wine.

In France, Germany, and other countries of the continent, these snails are at this day in great request for the table; and are chiefly in season during winter and the early months of the year. They are boiled in their shells, and then taken out, washed, seasoned, and otherwise cooked according to particular palates. Sometimes they are fried in butter, and sometimes stuffed with force-meat; but in what manner soever they are dressed, their sliminess always in a great measure remains. They are generally kept in holes dug in the ground, and are fed on refuse vegetables from the gardens.

189. The fourth order named zoophyta, exhibits animals holding a place between animals and vegetables. Most of them take root and grow up into stems, multiplying life in their branches, and deciduous buds, and in the transformation of their animated blossoms or polypes, which are endowed with spontaneous motion.

Sponge is an animal production and of this order: every minute pore on the surface of a perfect piece of sponge was the orifice through which a polypus kind of animal extended his feelers in search of food. Sponge, when first fished up from the sea is gelatinous, or a glue-like substance, and requires repeated washing in fresh water before it is fit for the several purposes to which it is applied.

190. Plants resemble zoophytes, but are destitute

of animation and locomotion: zoophites are plants furnished with sensation, and the organs of spontaneous motion.

Of the order zoophyta, some are soft and naked, and are called "zoophytes;" others are covered with a hard shell, and are denominated "lythophytes."

Large beds or rocks composed of the animal productions of this division are formed at the bottom of the sea. They derive their nutriment from insects, and from the saline and other matters in the sea. These, in their turn, are the origin of many of the chalk-beds, calcareous rocks, lime-stones, and other mineral articles.

191. The genus *hydra* or polype first deserves our notice. These curious animals are found adhering to the stems of aquatic plants, or to the under surfaces of the leaves.

The species are multiplied by vegetation, one, two, or more young ones emerging gradually from the sides of the parent animal: and these young again prolific, so that it is not uncommon to see two or three generations at once in the same polype. But the most curious particular respecting this animal is, its *multiplication by dissection.* It may be cut in every direction into minute divisions, and not only the parent stock will remain uninjured, but *every section will become a perfect animal.* Even when turned inside out, it suffers no material injury: for in this state it soon begins to take food, and perform all its other animal functions. And when one polype is introduced by the tail into another's body, the two heads unite and form one individual.

192. The hard or horny zoophytes, known by the name of *corals,* are equally of an animal nature with the polype. The whole coral continuing to grow as an *animal,* and form by secretion, the strong or stony part of the coral, which at once may be considered as its bone and its habitation, and which it has no power of leaving. Our hills are in many places full of them, and some rocks are entirely of their formation. Many seas are becoming every year more difficult to navigate, being nearly choaked up by the habitations of animals almost too small for human perception.

Some of the coral tribe have their animal part approaching more to that of a medusa, than of a polype. Of this kind are those numerous corals known by the name of *madrepores.* The smaller corals are termed *corallines*, or sea-mosses; and are actually so many ramified sea polypes, covered with a horny case, to defend them from the injuries which they would otherwise be liable to, in the boisterous elements in which they are destined to reside. The principal genera of the *corallines* are, 1. *Sertularia*, 2. *Tubularia*. 3. *Flustra*. Those of the *corals* are, 1. *Gorgonia*, Venus's fan. 2. *Isis*. 3. *Madrepora*. 4. *Millepora*. 5. *Tubipora*.

Coral is bought by weight; and its value increases in a certain ratio according to its size. Beads of large size are worth about 40s. an ounce, while small ones do not sell for more than 4s. Large pieces of coral are sometimes cut into balls, and exported to China, to be worn in the caps of certain orders, as an insignia of office. These, if perfectly sound and of good colour, and upwards of an inch in diameter, have been known to produce in that market as much as £300, or £400 sterling each. There are extant many beautiful pieces of sculpture in coral; since this substance has in all ages been considered an admirable material for exhibiting the artist's taste and skill. Probably the finest specimen of sculptured coral that are known are a chess-board and men, in the Tuilleries, which were the property of the late queen of Naples.

The Chinese have, within the last three or four years succeeded in cutting coral beads of much smaller dimensions than has been effected by any European artist. These which are not larger than pins' heads, are called *seed coral*, and are now imported from China into this country in very considerable quantities for necklaces. Nearly the whole of the coral that is used is of *red* colour; *white coral* being considered of little value either as an article of commerce or decoration. There are modes of imitating coral so exactly that without a close inspection it is frequently impossible to discover the difference betwixt the real and the counterfeit article.

193. The fifth order of the class vermes is called "infusoria," which are extremely minute animalcula, destitute of feelers, and generally invisible to the naked eye. They are chiefly found in infusions of various vegetable substances.

The vorticella is found in most stagnant and impure water, and is known by its constant rotary motion. Rain water collected in cisterns of almost any kind, and kept for some time, contains myriads of them.

Animalcules are shaped like fish, reptiles, eels, stars, hexagons, triangles, ovals, and circles; they have horns, probosces, &c; and although the eyes of many species are not discernible, yet they move about with inconceivable relative velocity in the fluids they inhabit, without interfering with each other.

194. Having thus given a popular view of the fifth order, we will exhibit it in epitome: we may carry miniatures about with us; full length figures we hang up in our apartments.

The orders of Vermes or Worms, are **1.** *Intestina:* **2.** *Mollusca:* **3.** *Testacea:* **4.** *Zoophyta: and* **5.** *Infusoria.*

I. Intestinal worms are simple and naked, without limbs: some of them live within other animals, as the ascarides and tape-worms: others in water, as the leeches; and a few in the earth, as the earth-worm.

II. Moluscous worms are simple animals without shell, and furnished with limbs, as the *cuttle-fish, medusa, star-fish,* and *sea-urchins.*

III. Testaceous worms are animals similar to the last, but covered with shells, as *oysters, cockles, snails,* and *limpets.*

IV. Zoophytes are composite animals, and appear to hold a rank between animals and vegetables: though they are in fact true animals, and possess sensation and voluntary motion. In many instances a great number of them inhabit the same stone, but some are soft, naked, and separate. The *coral, sponge,* and *polypes,* are instances of this order.

V. Animalcules are destitute of tentacula or feelers, and are generally so minute as to be invisible to the naked eye: they are chiefly found in different infusions of animal and vegetable substances.

Myriads of creatures (each too nicely small
Bare sense to reach) for thy inspection call.
In animalcules, germs, seeds, and flow'rs,
Live, in their perfect shapes, the little pow'rs.
Vast trees lie pictured in their slend'rest grains:
Armies one wat'ry globule contains.
Some, so minute, that, to their fine extreme,
The mite a vast leviathan will seem—
That yet, of organs, functions, sense partake,
Equal with animals of largest make;
In curious limbs and clothing they surpass,
By far the comeliest of the bulky mass.

THOMSON.

CHAPTER IX.

THE PHENOMENA OF ANIMATED NATURE.

195. THERE are numerous facts both instructive and amusing, which, though possibly belonging to distinct branches of science, yet possessing sufficient analogy to the phenomena of animated nature, to recommend themselves without the more formidable appearance of classification: we might arrange them under the respective heads of artificial, sentient, and insentient phenomena; but such a nicety is unnecessary in a mere selection of the wonders of Nature.

Centre of Gravity in Animals.

196. In man, the centre of gravity is such that the line of direction falls between his feet; the same is the case in quadrupeds. Rope dancers preserve their equilibrium by balancing long poles tipped with lead at each end.

Dogs and other four-footed animals find it difficult to stand upon their hind legs, as the centre of gravity lies too far forward, the heads of all animals being heavy in proportion to other parts of the body.

In the duck, the goose, and the swan, who are adapted for swimming, the centre of gravity lies pretty far forward: hence they walk awkwardly, and do not seem at ease but when in the water. Hawks have the centre of gravity so far forward, that when they light on the rocks they are obliged to stand with their heads up, somewhat in the manner of dogs. If they were to put themselves in any other position they would fall forward. Penguins are similarly formed, and their weight sinks them so deep in the water, that a stream passes between the neck and the body. In cats and animals that spring upon their prey, the centre of gravity is so situated that they uniformly fall upon their feet. When dropping from an height they hang down the fore and hind feet and tail, so as to bring the centre of gravity to a point below their breast, which, descending first, makes them fall as they do. Fasten a piece of lead or stone to the string of a bent bow, and toss the whole in the air, that part will come down first, and the back of the bow will never do so. The same cause acts in the case of cats and other animals of prey.

We are told, by voyagers and writers on Natural History, that tortoises are taken in warm climates whilst floating in a drowsy state on the surface of the waves. A man throws himself out of the boat and lays hold of the tortoise by the tail, and by his weight keeps it from diving, which gives his companions time to lay hold and drag it into the boat.

Experiments and Observations on the Formation of Bone, by T. Howship, Esq.

197. The following inquiry was principally suggested by the very beautiful results of the elaborate series of experiments on the composition of bone and cartilage, by Mr. Charles Hatchett; and the interesting nature of the subject engaged me to pursue it to the extent I have done.

An embryo, eight weeks old, was prepared by spreading out the limbs upon slips of glass, and allowing them to dry.

Upon examining these by the compound microscope, the following appearances presented themselves. Rings of bones had been formed in the situation of the metacarpal bones, and of the first and third phalanges. The diameters of these pieces of bone were much larger, in proportion to the length of those parts of the limbs within which they were forming, than at the future stages of their growth.

This was most evidently the case in the bones of the hand and foot: it appeared to be a provision for admitting of a considerable increase to the length of the cylinder, before it became necessary to enlarge its diameter.

In the embryo ten weeks old, the extremities of the bones were found connected together by a cartilaginous substance. The rings originally formed having, in the mean time, gradually increased in length, had now reached the cartilaginous portions at the extremities. The cartilage connected to the upper end of the bone of the arm was divided into thin sections, for examination under the microscope. Several irregular cavities were discovered in the substance of the cartilage, filled with a mucilaginous fluid. In one of these sections a smooth cavity was detected, which extended into an even canal or tube, passing down to the surface of union between the cartilage and the bone.

In order to ascertain more clearly the primary arrangement of the ossific matter, the lower extremity of the thigh-bone of a child, three weeks old, was macerated and cleaned. A longitudinal section of the bone was then made, and the surface of the section, including the margin of ossification, pared very smooth with a knife. The piece was afterwards calcined, with a view to remove the remaining animal matter.

In the examination of this, and many successive sections of a similar description, it was observed that, in proceeding from the middle of the cylindrical bones, where the medullary spaces are larger, and the cancellated structure stronger, towards the more recently formed extremities of the bone, the ossific masses become more numerous, of a lighter substance, and a thinner texture; the same gradation being continued up to the margin of the newly ossified surface, where the structure is most curiously wrought, and so exquisitely fine as scarcely to admit of description.

From these examinations it was ascertained that the first and earliest state in which the particles of ossific matter become apparent, after they have formed a mass by their cohesion, may be considered as an assemblage of the finest and thinnest fibres, moulded into the form of short tubes, arranged nearly parallel to each other, and opening externally upon the surface connected with the cartilage.

In order to observe the changes that occur towards the latter periods of growth, sections were taken from the lower end of the thigh-bone; these were selected from subjects of various ages, and the following were the appearances under the microscope.

In a child eleven months old, the canals within the cartilage were very few in number. At the age of four years these canals were still more thinly scattered, and those that were observed were of comparatively small diameter. When the sections became partially dry, a line, one-sixteenth of an inch in breadth, was seen towards the margin of ossification, where the particles of the cartilage had apparently taken on a new arrangement, so as to resemble parallel lines or fibres. This curious circumstance has been noticed by Haller.

At the age of eleven years the cartilaginous canals were found to be still diminishing both in point of size and number; and in the examinations made at seventeen years, it was with great difficulty that a section could be found in which there was any remaining trace of them.

Sections taken from the cartilages and ossifying extremities of the bones of the slink or fœtal calf, were examined in the microscope. The cartilaginous canals were found to be very numerous. They were all filled with a clear mucilage, and the sides of the canals in many parts of the cartilage had the appearance of being stained with blood, although no distinction of blood-vessels could be detected in any of them.

By a series of these examinations it was ascertained, that the cartilages upon which the flat bones of the scapula and ilium are produced, possess a similar organization to that which obtains in the cylindrical bones.

The posterior extremities were injected with coloured size, and the cartilage then examined in sections, under the microscope. The membranes covering the cartilages and bones externally were beautifully injected; the canals within the cartilage also were equally well injected. Wherever the canals appeared, they were observed to have received the vermillion.

Several oblique sections of canals fell under observation, and in those a membranous lining was very readily discerned, the injected state of the parts rendering the divided edge of the membranous tube very obvious. In some instances this membrane became still more evident, by its having been partially separated from the divided edge of the canal.

Where the canals were found to be divided longitudinally, the membranous lining was, in general, still attached to the sides of the tube, and the beautiful appearance of the injected membrane, was rendered still more brilliant by the abundance and crystalline transparency of its natural mucous secretion,

In many parts of the cartilage where the lining of the canals was finely injected, there was still no appearance of distinct vessels, although in those canals that were opened at their origin upon the external surface of the cartilage, a distinct artery, full of the injected matter, might generally be traced, passing inwards to some extent.

In the more internal canals, the usual appearance of the membranous sheath, under the microscope, was such as it would have been if the injection had passed out from the vessels, and become dispersed in the cellular texture of a fine membrane; had so peculiar an appearance arisen from the accidental rupture of the coats of the arteries, the injected matter must have been detected in masses, which was not in any instance the case.

In those canals that were divided obliquely, the finely and equally injected membrane had the appearance of an uniformly scarlet tube; and by increasing the magnifying power to a very high degree, the individual particles of the vermillion not only became visible, but were seen most distinctly; they were every where found to be very thinly and evenly scattered, indicating the most equal dispersion of the colouring matter throughout every part of the membrane.

In prosecuting this part of the inquiry, a considerable difficulty at first arose out of the following circumstance. The heat of the water, in which the preparation was laid previous to its being injected, had so far loosened the membranes from the sides of the canals, that in the subsequent operation of dividing the cartilage into sections, they were torn from their natural situation, and were consequently found in many parts more or less collapsed. These collapsed membranes had, under the microscope, very much the appearance of injected arteries, and were at first considered as such, but subsequent and more attentive observation soon enabled me to correct this mistake.

From the foregoing observations I think myself warranted in drawing the following conclusions.

1. That, in the mammalia, the first rudiments of ossification in the long bones are the effect of a secreting power in the arteries, upon the internal surface of the periosteum, which produce a portion of a hollow cylinder; this form of bone having been found antecedent to the evolution of any cartilaginous structure.

2. That, at a certain stage of the process, the mode of operating is changed, in order that it may proceed more expeditiously. A cartilage is formed, which, by the nature of

its organization, and by admitting of a specific provision of cavities and canals, lined with vascular membranes, which secrete an abundant store of gelatinous matter, is adapted to this particular purpose; while, at the same time, it serves to determine the future figure of the extremity of the bone, by establishing and conducting the ossification within its own substance.

3. That, from the appearance and texture of cartilage, when examined under the microscope, it may be defined— an even and finely granulated albuminous matter, deposited in the interstitial spaces of an exceedingly elastic bed of a semi-transparent reticulated structure, which is apparently a modification of gelatin.

4. That from the period when the ossification proceeds in the mode above described, by the medium of cartilage, the process is continued in the same uniform manner till it has completed the growth of the bone.. The growth of the epiphyses and their union with the ends of the bone, are also effected by the same means.

5. That the ossific matter in the cylindrical bones is deposited primarily in the form of fine thin tubular plates; a mode of deposition of all others the most favourable for their being subsequently remodelled, and for facilitating all the subsequent changes of structure they are destined to undergo.

6. That, while the circulation in the capillary arteries, situated between the cartilage and bone, must provide the phosphate of lime, the principal agent in extending the cylinder, and in effecting the subsequent progressive changes of structure, which, in a growing bone, are continually taking place, appears to be simply the mechanical pressure exerted by the fluid secretions within the medullary cavities of bone, this power operating successively in different directions, according to the particular determination given by the circulation.

7. That the mode of circulation most favourable for ossific action, is a very slow and uniform motion of the blood through the capillary system; and that the numerous inflexions of the minute arteries, in the pericranium, and the great weakness and rectangular mode of giving off the smaller arteries upon the dura matter, as well as the extremely curious appearance of the blood and injected matter, upon the fine membranous linings of the canals in cartilage, indicating, as I believe, something beyond a mere capillary circulation, are to be considered as so many evident provisions for securing this condition.

8. That in the formation of the cylindrical bones, the ossific surface is arranged into tubular plates of two different sizes, constituting a larger and a smaller series; an arrangement

by no means essential to the increase of a bone, because in many of the early stages of ossification, and also where the growth is very slow, the larger series is found to be entirely wanting.

9. That the only apparent use of the larger series of tubes, is that of augmenting the quantity of blood circulated through the ossifying structure, so as to increase the rapidity of growth, for they are abundant in animals of quick growth, less numerous in those that reach maturity slowly, and in the same animal I have observed they are employed by nature, or laid aside in conformity with the quick or slow developement of structure, which we know actually takes place at the particular period when the examination is made.

10. That in the growth of the cylindrical bones, and of those flat bones that are formed upon cartilage, the deposit of the ossific secretion is in the first instance made around the external openings of the smaller series of tubes, and upon these only. This opinion derives support from the recent appearance of the bones of quadrupeds, but is most clearly established by the characters found upon the ossific surface in the bones of birds, where the gradations of progressive evolution are more readily traced.

11. That in the flat bones of the skull, the circumstances under which ossification takes place, differ materially from those above described. In these the phosphate of lime, in combination with the animal mucilage, is occasionally deposited in small detached unequal masses, without regularity, as if merely laid in the way preparatory to their subsequent application; that these soon become connected with the more central parts of the bone, and are found to decrease in thickness as they increase in breadth, until they are finally consolidated with the original plate of bone.

12. That the particular simplicity observable in the mode of production of the bones of the skull, affords a strong argument in favour of the opinion, that pressure, variously modified, constitutes one of the most efficient instruments in the hand of nature; for in this instance, the uniform, though gentle pressure from the impulse of the circulation, and the constantly increasing volume of contents in the head, must be admitted to be the sole agents in completing that process, which, in its commencement, had the appearance of being conducted in a comparatively imperfect manner.

13. That the ultimate texture of bone is not laminated, but reticulated, the phosphate of lime being deposited as an intestinal substance; for, although, from the greater compactness necessary to the bones of quadrupeds, the ultimate structure is not in them so readily traced, yet in the more delicately constructed bones of birds, this mode of arrange-

ment is sufficiently obvious, and may at any time be readily ascertained.

Like leaves on trees, the race of man is found;
Now green in youth, now withering on the ground.
Another race the following spring supplies,
They fall successive, and successive rise;
So generations in their course decay,
So flourish these, when those are past away.

POPE.

Efficacy of Water in the Growth of Vegetables.

198. That vegetables will grow in woollen cloth, moss, and in other insoluble media, besides soils, provided they be supplied with water, has been repeatedly shown since the days of Van Helmont and Boyle: but the experiments of a modern author, from their apparent correctness, seem more highly interesting and conclusive.

Seeds of various plants were sown in pure river-sand, in litharge, in flowers of sulphur, and even among metal, or common leaden shot; and in every instance nothing employed for their nourishment but *distilled water*. The plants throve, and passed through all the usual gradations of growth to perfect maturity. The author then proceeded to gather the entire produce, the roots, stems, leaves, pods, seeds, &c. These were accurately weighed, dried, and again weighed, then submitted to distillation, incineration, lixiviation, and the other ordinary means used in a careful analysis. Thus he obtained from these vegetables all the materials peculiar to each individual species, precisely as if it had been cultivated in a natural soil,—viz. the various earths, the alkalies, acids, metals, carbon, sulphur, phosphorus, nitrogen, &c. He concludes this very important paper nearly in these extraordinary words: "*Oxygen* and *hydrogen*, with the assistance of solar light, appear to be the only elementary substances employed in the constitution of the whole universe; and Nature, in her simple progress, works the most infinitely diversified effects by the slighest modifications in the means she employs."

Difference in the Digestive Powers of Animals.

199. Mr. Majendie fed a dog upon sugar and distilled water. In about a fortnight it became lean. On the 21st day an ulcer appeared in the centre of the

cornea of each eye, which gradually increased, penetrated the cornea, and the humours of the eye ran out: the leanness continually encreased, the animal lost its strength, and died on the 32d day.

A second and a third dog fed likewise on sugar and water, shared a similar fate.

Two dogs fed on olive oil and water died on the 36th day, with precisely the same phenomena, except the ulceration in the cornea.

Several dogs were fed with gum and water; their fate was precisely the same, as was also that of another which was fed upon butter, and which died on the 36th day.

It is obvious that none of these articles (at least singly) are capable of nourishing dogs. But the inference that they cannot nourish man does not hold: for the Indian lives upon rice, and the Africans who go to the harvest of gum, carry no provisions with them, but live chiefly upon that vegetable production dissolved in water: and it is said that the negroes fatten upon sugar.

As to the dog, that he should perish upon vegetable diet is not surprising, as he is a carnivorous animal; but that the same result should take place from a butter diet is rather singular, it being an animal production. With man it is very different. He can live on vegetables only, either from choice or necessity, without the least detriment to his health: he also lives on vegetables with animal food; but he cannot live on animal food alone. What man can exist without bread? that article which he himself calls the staff of life! The fact is that the gastric juice in the two animals, the man and the dog, possesses different properties, consequently their powers of digestion are different. Who could think of offering a beef-steak to a cow?

Singular Abstinence of a Pig.

200. A pig was buried in its stye by a fall of part of the chalk cliff under Dover Castle, December 14, 1810. On the 23d of May, or 160 days after the accident, the pig, still alive, was extricated from its confinement.

Its figure was extremely emaciated, having scarcely any muscles discernible; and its bristles were erect, though not stiff, but soft, clean, and white. The animal was lively, walked well, and took food eagerly. At the time of the accident it was fat, and supposed to have weighed about 160lbs;

but it now weighed only 40lbs. At the time of the fall there was neither food nor water in the stye, which is a cave about six feet square, dug in the rock, and boarded in the front; and the whole was covered about 30 feet deep in the fallen chalk. The door and other wood in front of the stye had been much nibbled, and the sides of the cave were very smooth, having apparently been constantly licked for obtaining the moisture exuding through the rock.

Anthropophagism.

201. Anthropophagism (that horrible disposition of certain individuals, and even of whole nations to employ the flesh of their own species as food), has often excited the reflections of physicians and moralists, who have wished to discover the sources of so revolting an aberration from humanity.

Famine has been, without doubt, one of the most frequent, and most excusable causes of anthropophagism. The Arabian Abdallatif has left us a frightful picture of the effects of a famine in Egypt: the putrified remains of animals, ..., all the most disgusting of objects were devoured with avidity. The want of food became so urgent, that flesh was torn from dead human bodies; children were strangled by their parents, for the purpose of feasting on their flesh; and bands of express anthropophagists traversed the whole country. It is only necessary to consult the histories of shipwrecks, in order to ascertain to what an extent excessive want may change the character and moral disposition of man; and, to remove all doubt of the existence of such horrors, civilized, and till then, sensible beings will be seen to have attended to nothing but the impetuous desire to calm the torments of famine, and have determined, by the indications of chance, which of their companions shall serve as food to the survivors.

202. A love of revenge has sometimes rendered men anthropophagists; and, although we may suppose that famine originally led hordes of cannibals to devour their prisoners, it cannot be denied that the fury of vengeance has, at least, perpetuated this crime amongst them.

Dr. Robertson gives his decided opinion, that revenge was the first cause of anthropophagism. It was not scarcity of food, he says, as some authors imagine, and the importunate cravings of hunger, which forced the Americans to those horrid repasts on their fellow-creatures. Human flesh was never used as common food in any country; and the various relations concerning people who reckoned it among the stated means of subsistence, flow from the credulity and mistakes of travellers. The rancour of revenge first prompted men to this barbarous action. The fiercest tribes devoured none but prisoners taken in war, or such as they regarded as enemies.

I go to fight to revenge the loss of our brave fellows that were slain; I will be as merciless as the famished wolf: I will exterminate and devour our enemies; the tanned skins of their battered skulls shall hang in my dwelling; I will crush their wives and children, like the fearful storm of pouring hail; like the mighty thunder will I consume their devoted villages:—such is an ancient war-song of the savages of Louisiana, and such is generally the spirit of those of all nations of cannibals: the battle-shout of the Iroquois is,—"*We go to devour our enemies!*"

203. Religious opinions have also had some influence in producing the horrible custom of which we treat. Human sacrifices were in use among several ancient nations; and it was not strangers alone who were immolated, since parents delivered up the dearest objects of their affection, their own children, to the knife of the sacrificer. There is but one step from such an atrocious practice to that of anthropophagism; and the history of an almost civilized people, the Mexicans, who, wanting none of the necessaries of life, regaled themselves with the flesh of the human victims that were offered to their idols, proves that in them, at least, it was not famine that gave rise to such odious banquets.

204. A fourth and last cause of anthropophagism especially demands the attention of the physician and the legislator: it consists in a depravation of the will, which has become subjugated to a depraved appetite. Although examples of such a deplorable state are very rare, yet modern times have furnished us with several such instances; amongst which, that of an anthropophagist of the environs of Wilna, the history of which was published by Professor Gruner, of Jena, is one of the most remarkable.

John James Goldschmidt, a cow-herd, was married at the age of twenty-seven, and continued to follow the above-mentioned occupation for twenty-eight years, without any other moral vices being remarked in him than a certain rudeness and grossness of manners, and a great inclination to violent anger. He was fifty five years of age in the year 1771, when a great part of Germany was oppressed with famine; this circumstance, however, cannot be considered to have influenced the crime of Goldschmidt, which was committed in a fit of passion, since he had obtained provisions the day previously to it; he was not involved in debt, and his yard was stocked with poultry. This unfortunate man met with a young traveller at the entry of a forest, whom he reproached with having worried his cattle; the stranger asserted that he had not done this: a dispute and contest followed, and Goldschmidt killed the traveller by a blow with his stick. In order to conceal this circumstance from the public, he dragged the body of his victim into a thick part of the wood, cut it into small pieces, and carried one of them with him in his bag every time he returned to his dwelling. It was in one of those journeys that the desire to taste human flesh first developed itself in him: he boiled and roasted some part, and ate of it, with his wife, to whom he described it as mutton. A year afterwards he enticed a child into his house, killed, and ate part of it. The crime was discovered, and it was from the confession of the culprit that the details we have given were obtained, besides many others still more revolting, which we have thought proper to pass over in silence.

205. A Milanese woman, named Elizabeth, from this cause, is said to have had an inconceivable desire for human flesh; and, in order to satisfy it, enticed children into her house, where she killed and salted them; but a discovery having been made, she was broken on the wheel and burnt in 1519.

206. Mr. Percy, a surgeon-in-chief to the French army, has also reported to the National Institute a case of voracious appetite, which extended to the desire for human flesh. The subject of it was a young man from the neighbourhood of Lyons, named Tarare, and who, in early life, belonged to a troop of strolling jugglers. In the exercise of his calling he accustomed himself to swallow stones, great quantities of broken metals, baskets full of fruit, and even living animals. In consequence of these dangerous practices, alarming symptoms supervened; notwithstanding which, he was unable to abandon them. At the commencement of the late war, he was enrolled in the army of the Rhine, and, not satisfied with the allowance of food which he received, was in the habit of seeking for the necessary supply around the moveable hospital. The refuse of the kitchens, rejected matters, corrupted meats, &c. did not suffice him; he frequently disputed with the lowest animals for their disgusting food, and was constantly in search of dogs, cats, and even serpents, which he devoured alive: he was obliged to be driven, by force and threats of punishment, from the places where the dead were lying, or where blood drawn from the sick was deposited. Endeavours were made to cure his ravenous appetite by giving him fat, opium, acids, and powdered shells, but in vain. In consequence of the disappearance of a child of sixteen months old, horrible suspicions were entertained

of Tarare, and he fled. Five or six years afterwards he was received into the hospital at Versailles, labouring under a consumption of which he soon afterwards died.

207. These facts led Hermann Gruner to form some very judicious reflections on this subject, with an abstract of which we shall terminate this article.

However criminal murder may be, particularly when it is followed by anthropophagism, the reality of a state cannot be contested where this has been induced by a depraved appetite independent of the will. Nothing is more astonishing than the caprices of pregnant women, whom an insatiable inclination leads to enjoy with delight the most disgusting objects. Here, a fault of education, or the empire of a perverse habit, cannot be accused as the cause of such an aberration. The most serious remonstrances have no effect when advanced in opposition to an inexplicable desire, the satisfaction of which is demanded by nature in the most urgent and irresistible manner. May not this be equally applicable to the appetite of some individuals for human flesh? Whatever may have been the original cause of it, it depends principally on a disordered imagination: the appetite once indulged, it becomes increased, and at length habitual.

208. Many other criminals besides Goldschmidt, have conceived this ardent inclination for feeding on human flesh only after having committed homicide. This disposition has also several times appeared in women in a state of pregnancy; an horrible proof of which is related by Abdallatif. At other times, anthropophagism has been observed as a family-evil: Hector Boëthius relates an instance of this in his History of Scotland. A Scotch free-booter, his wife, and children, were condemned to be burned for having drawn several persons to their dwelling, murdered, and devoured them. The youngest daughter was, however, exempted from this sentence, in consequence of her tender age; but she had hardly attained her twelfth year, when from having perpetrated the crime of her parents, she was submitted to the same punishment.—"Why do you express disgust at my conduct?" said this young monster to the spectators, who were testifying their horror and detestation; "if you knew how delicious human flesh was you would all eat your own children!"

Let us conclude with Dr. Gruner, that such desires, the idea alone of which should make the most insensible of men tremble with horror, ought really to be considered as a state of disease; and that physicians should thus interpret them to the expounders of criminal law.

Instances of suspended Animation.

209. The following was related by the celebrated Dr. Moyes.

A short time before the French revolution, an American gentleman resident in France, after a sudden attack, apparently died. At that time it was not easy to obtain burial for Protestants in consecrated ground; the difficulty, however, was at length got over, by a secret agreement with the monks of a neighbouring convent, who had promised to come at dead of night to take away the body, and inter it in their own chapel. The corpse was accordingly laid out and prepared for sepulture; and a friend of the deceased attended, to deliver it into the hands of the monks. This was thirty-six hours after the gentleman had appeared to expire.

Midnight was now arrived, but no monks appeared; the friend waited in expectation of them for a considerable time; but finding that he waited in vain, he at length determined to retire to his own home. Before, however, he quitted the remains, he wished to take a parting look at his old and valued friend. He approached the coffin, and gently took hold of one of his lifeless hands. To his utter astonishment, he perceived a slight degree of warmth in the limb, he then applied his hands to the other parts, and clearly felt the same effect. Overjoyed at the circumstance he immediately called in some attendants; ordered the body to be put into bed, and kept warm; and every method to be used for the restoration of life. The endeavour was crowned with success; and in a short time his friend was restored to life and sense, and lived for many years to relate the story of his own resuscitation, and providential escape from premature inhumation.

210. The following singular event occurred in 1767 to a Mr. Stone, who lodged at the house of a Mr. Seaman, in Charles-Town, South-Carolina. He had been waiting the issue of a law-suit of great importance, and was in a state of much anxiety. One night, having at supper ate heartily

of toasted cheese, and being much fatigued, he retired early to bed.

The next morning his servant went, as usual, into his chamber to call him; and found his master apparently a lifeless corpse. Mr. Seaman, on being apprised of the circumstance, instantly dispatched a messenger for the doctor, who soon arrived; but finding the body cold and stiff he conceived it useless to attempt any means of restoring animation. He gave it as his opinion, that Mr. Stone had expired shortly after he had gone to bed, and that no hopes of resuscitation remained.

In consequence, Mr. Seaman secured his friend's papers, money, &c. sent for a person to make his coffin; and gave directions for his funeral on the ensuing day:—dispatch being absolutely necessary in so hot a climate. The carpenter having measured Mr. Stone, in the presence of Mr. Seaman, they retired together; the latter locking the apartment, and putting the key in his pocket. Early in the evening the coffin was brought home, and Mr. Seaman accompanied the man to the chamber, to bid his friend a last adieu.

On approaching the corpse he was astonished to perceive the left hand and arm of Mr Stone removed from the side where he had placed them, and stretched out in an horizontal position. He took hold of the extended hand; and though it was still cold, he determined that his friend should not be removed from the bed till he had been again seen by the medical gentleman, who had attended in the morning.

The doctor came accordingly a second time; and soon discovered symptons that manifest the presence of the vital principle. Proper means for restoring animation were instantly adopted, and soon crowned with success. Mr. Stone was brought back to life, sense, and health; and after continuing abroad another year to finish his business, he returned to his wife and family in England.

To them he related circumstantially the account of his providential escape; and declared that he was *sensible* at the time the man was measuring him, of the purpose for which he was doing it, and that he suffered extreme agitation and distress at the idea of being interred alive, though he had no power to indicate his consciousness.

He said that *he retained, and ever should retain, a perfect recollection of what his feelings were upon that occasion;* but as they were rather such as are excited by an imperfect dream, or an attack of the night-mare, than those vivid ones, which the mind experiences when its faculties are alert and unimpaired, he conceived they were not sufficiently strong to produce any great effect upon the muscular system. He believed, however, the removal of his arm was the consequence of an imperfect struggle; though he certainly could not have made the efforts which *he imagined* himself to have done; such as speaking to his friend, assuring him that he was alive, and entreating his protection.

Mr. Stone survived the event ten years.

Account of a White Female, part of whose Skin resembles that of a Negro.

211. Hannah West was born of English parents, in a village in Sussex, in 1791, about three miles distant from the sea. Her parents had nothing peculiar.

Her mother, who is alive now, (1820), has black hair, hazel eyes, and a fair skin, without any mark. Hannah was her only child by her first husband; but her mother has had eleven children by a second marriage, all without any blackness of the skin. The young woman is rather above the middle size, of full habit, and has always enjoyed good health. Her hair is light brown, and very soft; her eyes faint blue; her nose prominent, and a little aqualine; her lips thin; the skin of her face, neck and right hand very fair, in every respect, indeed, she is very unlike a negro; it is, consequently, very singular, that the whole of her left shoulder, arm, fore-arm, and hand, should be of the genuine negro colour, except a small stripe of white skin, about two inches broad, which commences a little below the elbow, and runs up to the arm-pit, joining the white skin of the trunk of the body.

Women with Beards.

212. Of women remarkably bearded we have several instances. In the cabinet of curiosities of Stutgard, in Germany, there is the portrait of a woman called *Bartel Graetje,* whose chin is covered with a very large beard. She was drawn in 1587, at which time she was but twenty-five years of age. There is likewise in the same cabinet another por-

trait of her when she was more advanced in life, but likewise with a beard.

It is said that the duke of Saxony had the portrait of a poor Swiss woman taken remarkable for her long bushy beard; and those who were at the Carnival at Venice, in 1726, saw a female dancer astonish the spectators not more by her talents, than by her chin covered with a black bushy beard. Charles XII. had in his army a female grenadier: it was neither courage nor a beard that she wanted to be a man. She was taken at the battle of Pultowa, and carried to Petersburg, where she was presented to the czar in 1724; her beard measured a yard and a half. We read in the Trevoux Dictionary, that there was a woman seen at Paris, who had not only a bushy beard on her face, but her body likewise was covered all over with hair. Among a number of other examples of this nature, that of Margaret, governess of the Netherlands, is very remarkable. She had a very long stiff beard, which she prided herself on; and being persuaded that it gave her an air of majesty and consequence she took care not to lose a hair of it. Eusebius Mierembergius mentions a woman who had a beard reaching to her navel.

Change of Colour from Brown to White in a Native of Bengal.

213. J. W. aged fifty-six, a native of Bengal, (his parents Mahometans, and both dark,) left India about the age of ten or eleven, and has since resided in Edinburgh, chiefly performing the office of a servant; but for the last nine or ten years he has worked as a mason's labourer (1818.)

During this period he has gradually lost his native dark colour, and become white, which he attributes partly to the climate, and partly to the action of lime and mortar in his occupation as a mason, which occasioned much itching of the skin. The change commenced in the hands and head; the hair from being black and lank, has become light grey, and somewhat curled. The parts which last retained their colour were the breast and the back of the neck. The only remains of his original complexion at present are some irregular patches of a dull purplish colour, covering the upper parts of the cheeks and prominences of the ears, and a lighter patch at the tip of the nose. During the change of colour, no sensible alteration was observed in his health.

Case of a Child aged Six Months, who swallowed a double-bladed Knife without Injury. By W. Banks, Esq. Surgeon.

214. On March 16th, 1802, a child of Jonathan White's, Southgate, Chichester, about *six months* old, had a small double-bladed knife, about two inches and a half in length, given it to play with. On the return of its mother to the room, she sought in vain for the knife, in all parts of the cradle in which the infant was lying: the child expressed some uneasiness at the stomach, from which the mother concluded it had swallowed the knife; the bowels were kept lax by the use of castor oil; and the fæces soon began to grow black. The child took no food, but milk; seemed often very uneasy in its stomach, and had slight febrile indisposition; yet it continued to look well, and was sufficiently fat.

May 24th. The shortest blade was discharged by the bowels; the back of it very much corroded, its edges being ragged, uneven, and saw-like: the rivet was entirely dissolved. The general state of the child's health as stated above.

June 16th. The child after being for a day or two more than usually uneasy, and rejecting every thing offered as food, brought from its stomach in vomiting, one side of the horn handle about two inches in length, very much softened and bent double: a small bit of iron was passed a few days afterwards by stool. He frequently expresses great pain in his stomach and bowels, and starts much when asleep; has retained no nourishment for three days, and now looks much emaciated.

July 8th. The child more emaciated, takes little food, and unless when quieted by a decoction of poppies expresses more pain, continually writhing. Its bowels are lax, and the stools have a black appearance, and the abdomen exhibits externally a degree of inflammation. His pulse is soft and moderate while asleep; the skin feels rough; has voided nothing since the horn handle.

July 24th. To day he passed a bit of iron, which was about half an inch in length, of a wedge-like shape, much corroded, and full of holes, and appearing to have been the large blade.

August 11th. The child has been in a convalescent state for the last fortnight, grows fatter, and looks much better; has been more quiet, although he has not slept much; the decoction of poppies has been omitted for some time past; the pulse full and strong; sucks more heartily, and now eats sopped bread three or four times a day. Yesterday and to-day it has been more uneasy: about five o'clock in the evening vomited up its milk, together with the back of the knife, two inches and a half in length, pointed, and corroded at one end; the *other* nearly perfect, and *first* presented itself at the mouth; soon after, it vomited the other side of the horn handle, softened, the edges uneven, and dissolved. The child was much exhausted by its efforts, and soon fell asleep. The stools are some days of their natural colour, and sometimes black.

Dec 20th. The child is now in perfect health, remarkably robust, and has not experienced a day's illness since August.

Whether we look on this case, as proving the possibility of so large a substance as a knife remaining so many months without material injury, in the stomach of so young an infant, or whether we consider the state in which the separated parts of the knife, at distant intervals, came away, it affords equally curious and useful matter for contemplation. It shews the remarkable power possessed by the gastric juice, even in so young an infant, of acting upon the metal, by which the rivets of the knife and the sharp edges of it were dissolved, and the life of the individual saved.

Remarkable Memory.

215. William Lyon, a strolling player, who used some years ago, to perform at Edinburgh, and who was excellent in the part of Gibby the Highlander, gave the following surprizing instance of memory.

One evening, over the bottle, he wagered a crown bowl of punch, (a liquor of which he was very fond) that he, next morning at the rehearsal, would repeat a Daily Advertiser, from beginning to end. Next morning he was put in mind of his promise and rallied for making so foolish a wager when drunk. To the surprise of all however he pulled out the newspaper, and gave it to one of them to witness that he could repeat every word verbatim. This he accomplished without making the slightest error, in a jumble of advertisements, price of stocks, home and foreign news, accidents, offences, and law intelligence;—this exertion of memory was certainly surprising; and is a lasting monument of great abilities abused by drunkenness.

The Rev. Dr. Macklin relates that a man waited on the Greffier Fagel, to display the wonderful memory which he possessed; offering to give any proof of it that might be required. A newspaper was lying on the table, and he was requested to read it through, and then repeat it verbatim. He accordingly did so, not omitting a single syllable, running through the title, paragraphs, advertisements, and colophon, in regular succession.

The Greffier Fagel expressed unbounded astonishment at such a wonderful instance of recollection. "Oh," replied the man, "this is nothing! shall I now repeat the same backwards?" "it is impossible" returned the Greffier. "By no means," said the other, "if you have patience to hear it;" and without the least hesitation, he repeated every separate article, beginning at the colophon, and ending at the title.

Female Courage.

216. In the year 1756, an half-ideot who was employed by a grocer residing in a town in Oxfordshire, was told, on the morning of the 5th November, to go to a coffer where the gun-powder was kept, and bring some down, and put it into the drawer, to supply the consumption of the evening;

The man forgot the order till it grew dusk, when he took a lighted candle in his hand, which he inserted in the loose powder; and, filling the measure, walked away.

He could not speak intelligibly, although he understood what was said to him; he made his meaning known by signs.

Scarcely had he emptied the powder into the drawer, when, suddenly recollecting what he had done, the terrified creature made the most terrible noise, displaying every mark of horror and dismay; and soon made his master and the family clearly understand, that he had left a burning candle fixed in the gun-powder!

The danger was so appalling, that most of the inmates fled; but a servant girl entreated her master not to alarm his sick wife: and, going direct to the chamber as gently as possible, approached the burning candle. Closing the fingers of her hands, she formed a kind of candlestick; and, lifting the candle safely out of the powder, returned with it to her master, fainting away the moment she reached the shop!

Wonderful Musical Talent.

217. There lived a man in Tottenham-Court-road, who possessed a very extraordinary musical and imitative genius. He was a man of fortune and under five feet high. He played upon two violins at one time; and imitated the organ, French horn, clarionet, trumpet, and kettle drums in so surprising a manner, as to make them appear as a whole band, with different people singing at the same time.

He principally played pieces of music out of Handel's oratorios. He could also imitate a carpenter sawing and planing, the mail coach horn; a clap of thunder, a fly buzzing about a window, a flock of sheep with hogs after them, a sky-rocket going off; tearing a piece of cloth, the bagpipes, the hurdygurdy, staccato, and generally finished his performance with beating a dog out of the room; this last is generally accounted the most *inimitable* imitation of all.

A Nest of a Singular Construction.

218. In June 1819 a laundry-maid at Darley Abbey, near Derby, spread out in an open drying-ground, amongst other things, five yards of narrow leno muslin, in two pieces; in a short time she missed them, and sought for them in vain.

Two days after, with many other articles, she laid out five yards of lace, in five separate pieces, which also soon disappeared; and every possible enquiry was made about them, but they could not be found. Within a week, a labourer saw something white hanging out of a tricecock's nest, at the distance of eighty yards from the drying-ground, and having heard of the loss of the lace, &c. he took down the nest, and the leno and lace were found within it, beautifully interwoven and twisted amongst the twigs so as to form a complete lining Unfortunately, the nest, which was a real curiosity, was pulled to pieces, and the whole ten yards were taken out uninjured and unsoiled. What a lesson this little circumstance teaches us, not to suspect too lightly those around us; and how forcibly it reminds us of the interesting drama of the "Maid and the Magpie."

Natural History of the Insects and Caterpillars which ravage Fruit-trees.

219. It is certain, insects of every description abound more some years than others, and their coming is sometimes supposed to be so sudden, as to give rise to the belief that they are brought by the winds. When the nature and mode of propagation of the different insects which exist on vegetables are duly considered, there will appear no necessity for such a mysterious conveyance. The greatest injuries to vegetables are occasioned by the caterpillar tribe, at a time when in the caterpillar state, and by the aphis and coccus.

As each of the caterpillar tribe is alike in its nature, it will be perfectly useless in a work like this to attempt enumerating or describing the different varieties: all exist in four different states during the year, and undergo as many changes; and from the smallest maggot to the largest caterpillar, each passes from an egg to a larva, maggot, grub, or caterpillar, from this to a chrysalis, and from that to a fly, beetle, chaffer, moth, or butterfly.

We first discover a maggot or caterpillar of a peculiar kind, devouring particular vegetables, the largest of those being produced from an egg smaller than the smallest pin's head, is at its birth very diminutive, and consequently seldom noticed, till it has made very considerable progress towards maturity; and as during their growth they are constantly made the prey of birds and other insects, these little creatures are endowed with a wonderful instinct for self-preservation; most possess the means of quickly secluding themselves on the approach of danger, or of letting themselves down gently to the earth, or other support, by a web; and such as do not, are of such plain or variegated colours as assimilate with the substance they feed on, and which thus deceive the eye.

It is in the caterpillar state that they are most easily discovered, and most in our power, and indeed when they are most mischievous, by devouring the leaves and buds: a gardener, should then seize every opportunity to destroy them.

There is no species peculiar to the plum, peach, nectarine, &c. but there is to the cherry; these, in the winged state, are a small dark brown moth, about half an inch in length, and are in activity when the fruit are about half grown; they then deposit their eggs on the new-forming buds, and as the coverings of those are enlarged, they enclose the eggs, and completely shield them from injury until the following spring, when, as the buds open, the eggs are exposed to the sun, and bursting into life, the caterpillars immediately commence their depredations on the young leaves and fruit.

These caterpillars have the power of bringing two or more leaves in close contact, and of fixing them together by a web, and thus forming a home, from whence they emerge in the night, and to which they retreat again before day; whenever, therefore, two leaves are seen sticking together, they should be examined, and the caterpillar or maggot destroyed; in doing this, some care is necessary, for, as if aware of meditated destruction, on the least disturbance it slips from its cell, and drops to the earth, where it quickly hides itself until night, when it again ascends.

The apple tree is infested with an insect of a very similar description, and requires the same attention to protect it.

There is also another maggot, which preys on the young branches of the apple tree in a peculiar manner; it penetrates near the point of the young growing shoots, and eats its way down the centre or pith; the young shoot of course then withers and dies, and to a superficial observer, without any perceptible injury; whenever, therefore, this is seen, the top should be cut off, the whole of the maggot will then be discovered, down which it should be traced to its end, and destroyed.

These insects, as they often stop the growth of the leading branches, are a most obnoxious obstruction to the training of young trees, and therefore cannot be too carefully looked after; and, it must be observed, that whenever one is discovered, although on an useless collateral, it should be destroyed, for if suffered to attain maturity, it may be the means of distributing hundreds of eggs the next year on the more important branches.

These caterpillars or maggots make their appearance with the buds, but are at first very small; as the leaves advance, these grow, and about the end of April, or beginning of May, become mischievous.

Whenever the leaves are seen folded or sticking together, pressing them between the thumb and finger will crush the insect, and in this manner a great number may be destroyed in a day.

A peculiar caterpillar is sometimes produced on the currant and gooseberry bushes, in such numbers that they devour all the leaves, let the number of trees be ever so great; on any sudden shock of the tree, they generally fall off, but unless then crushed or destroyed, they soon rise again; the most effectual method of effecting the destruction of such, is to spread a sheet or cloth under the tree, so that it may catch them when they fall; and then giving the trunk or branches a smart shock, by kicking against or striking them with a large pole or stick, the caterpillars will fall off upon the sheet, and are then easily collected and destroyed.

Mr. Knight observes, "an insect whose attacks on the apple-tree are often almost entirely destructive of its fruit, is a small brown beetle; this insect, when very minute, and long before it assumes the winged state or form, penetrates the blossoms by perforating one of the petals, and having gained possession of its internal part, prevents its further expansion by means of its web, and destroys those parts of it on which the existence of the future fruit in a great measure depends."

Peach trees are sometimes devoured by a species of chaffer or beetle, which shelter themselves in the crevices of old walls, or in the shreds, during the day, and from whence they emerge in the night, and commit their depredations.

Although those insects and the caterpillar tribes are very destructive, they are not so great a nuisance to the peach and nectarine tree as the aphis, or plant-louse.

The sudden appearance and rapid encrease of these insects, (which are called blights) most probably gave rise to the belief that they were conveyed by the winds.

Luminous or Phosphorescent Animals.

220. These are very numerous, though they have never hitherto been arranged into any distinct classification, or tabular form. They consist chiefly, and almost exclusively, of *insects and zoophytes; molluscuous worms;* though instances are occasionally met with among other worms. Insects furnish nearly a dozen distinct genera, of which almost all the species are luminous. The chief are the lampy-

ris, or glow-worm, and fire-fly tribes; the fulgora, or lantern-fly; the scolopendra, or centipede; the fausus spœrocenus; the elater noctilucus, and the cancer fulgens.

Among the worm-class the principal are the phloas, or pholas, as it is now generally, bnt erroneously denominated, the pyrosoma, the medusa phosphorea, the nereis nocticula, the pennatula, or sea-pen, and various species of the sepia or cuttle-fish. The atmosphere in some parts of Italy appears occasionally to be on fire, in the evening, from the great quantities of one species of the lampyris that throng together. A single individual of the South-America fulgora, fixed upon the top of a cane, or other staff, will afford light enough to read by. The streams of light that issue from the elater noctilucus are so strong in the night, that even the smallest print may be read by their lustre.

221. The *acudia* or fire-fly is of the beetle kind and inhabits South-America. The natives use them instead of candles, putting from one to three of them under a glass. Madame Meiran says, that at Suriucun, the light of this fly is so great, that she saw sufficiently well to paint and finish one of them in her work on Insects.—The largest of the acudia are said to be four inches long, and to shine like a shooting star as they fly. They are thence called *Lantern-bearers*.

222. The pyrosoma, when at rest, emits a pale blue lustre; but when in motion a much stronger light, variegated by all the colours of the rainbow. The phloas secretes a luminous juice, every drop of which illuminates, for a length of time, whatever substance it falls upon, or even touches; and the animal, after death, may be preserved so as to retain its luminous power for at least a twelvemonth. The noctilucent nereis often illuminates, by its numbers, the waters it inhabits, to a very considerable extent; and gives so bright a splendour to the waves, that, like the atmosphere when lighted up by the lampyris italica, they appear as though they were in a full flame. The organ from which the luminous matter is thrown forth, in these different animals, is of a very different character, and placed in very different parts of the body; sometimes in the head, sometimes in the tail, sometimes in the antennæ, sometimes over the surface generally.

Depredations committed by Locusts in Germany. Extract of a Letter from a Gentleman at Breslau, to his Friend in London. August 27, 1754.

223. I take this opportunity of sending you a melancholy journal of the mischiefs done here by the locusts, which has been carefully collected, and upon the truth of which in every respect you may safely depend.

On the 20th of this month an incredible multitude arrived at *Lampersdorff*, in the *Bernstadt;* there they formed in a column, and taking flight about noon, continued their passage for four hours over the forest of *Minchen*. These insects having passed the *Oder*, settled in the country about *Ohlau*, and after eating up every thing that was to be found at *Rothland* and *Beckeren*, they continued their passage again to *Ielsch*. On the 23d another swarm of these devouring creatures came from *Patschkau* to *Ober Schreibendorff*, where they fell upon two gardens and ruined every thing that was in them. As they were a little straitened in their quarters, they lay one upon another in heaps, to the height of one's knee, and being driven from thence they eat up all the grass in the meadows, and even all the rushes and reeds about the village of *Deutsch Jackel;* and from thence they continued their flight to *Hoben Giersdorff*, where they destroyed several fields of buck-wheat. As yet we have no farther account of the excursions of this body. A third prodigious swarm passed in the evening of the 22d by *Zinckel*. On the 23d they fell about *Losdorff*, on the 24th they passed by *Schonbrun*, *Prieborn*, and *Sibenhuben* and at length took up their quarters in the village of *Datzdorff*, where they lay one upon another a quarter of a yard high, taking up a quarter of a league in length, and about half that space in breadth. All the fruits of the earth that are not got in, as well as the grass, reeds, and in short every green thing, is totally destroyed. They tried at first to drive them away, at length somebody very luckily thought of beating a drum, upon which they immediately took flight, but settled soon after upon the trees in the forest, from whence they were driven by the same means. They made their retreat by *Munsterberg*, and then passed through the county of *Glatz* into *Bohemia*, where they have committed dreadful devastations on the lands of count *Wallis*. These insects are about the length of one's finger, and of all colours, grey, green, yellow, black, red, and brown. Some people pretend to say, that each of these bands has a captain of a most enormous size; this is certain, that they leave behind them an intolerable stench. Some of the inhabitants of the country have observed, that they make holes in dry earth, about the depth of one's finger, where they lay their eggs; which the peasants are endeavouring to destroy by double plowing their land. It is very remarkable, that the same evening they quitted *Lampersdorff*, three great swarms of winged ants passed by the same place, as if they had been in pursuit of them. Some people were foolish enough to endeavour to stop them, but as this drew the whole swarm upon them they were quickly weary of that sort of diversion.

Microscopic View of Spiders weaving their Webs.

224. Of all the beautiful discoveries with which we have become acquainted, through the progress of the physical sciences, there are none more striking than those of the microscope, or which may be studied with greater ease. The application of a powerful lens to any of those minute objects which we have it daily in our power to examine, exhibits a scene of wonder, of which those who have never witnessed it cannot form an adequate idea.

For example, the construction of cobwebs, has in all ages been lightly esteemed: nevertheless, for simplicity of machinery and neatness of execution, they cannot be surpassed by the art of man. The spinners are the apparatus through which by a most wonderful process the spider draws its thread. Each spinner is pierced, like the plate of a wire-drawer, with a multitude of holes, so numerous and exquisitely fine, that a space often not bigger than a pin's point includes above a thousand. Though each of these holes proceeds a thread of an inconceivable tenuity, which, immediately after issuing from the orifice, unites with all the other threads, from the same spinner, into one. Hence from each spinner proceeds a compound thread; and these four threads, at the distance of about one tenth of an inch from the apex of the spinner, again unite, and form the thread we are accustomed to see, which the spider uses in forming its web. Thus a spider's web, even spun by the smallest species, and when so fine that it is almost imperceptible to our senses, is not, as we suppose, a single line, but a rope composed of at least four thousand strands.—But to feel all the wonders of this fact, we must follow Leuwenhoeck in one of his calculations on the subject. This renowned microscopic observer found, by an accurate estimation, that the threads of the minutest spiders, some of which are not larger than a grain of sand, are so fine, that four millions of them would not exceed in thickness one of the hairs of his beard! Now we know that each of these threads is composed of above 4,000 still finer. It follows, therefore, that above 16,000 millions of the finest threads which issue from such spiders, are not, altogether, thicker than a human hair.

In the earlier part of last century, Bon of Languedoc, fabricated a pair of stockings and a pair of gloves from the threads of spiders. They were nearly as strong as silk, and of a beautiful grey colour!

Sulphate of Zinc (White Vitriol) devoured by Spiders.

225. For the knowledge of this fact, one of the most curious yet observed, as connected with the food of the insect tribes, we are indebted to the sagacity of Mr. Holt.

A quantity of sulphate of zinc, which he kept in a paper, disappeared, except a small external crust, in the centre of which was a large spider. To determine whether this insect, of the species called *aranea scenica*, had devoured the salt, he was put in a box with fresh sulphate of zinc, which he devoured in the same manner, converting it into a yellowish-brown powder. This matter was found lighter than the sulphate of zinc, from which it had been formed by the spider. It was insoluble in water, and appeared to have been deprived of a portion of its acid.

Curious Account of the Economy of Ants by J. Strutt, Esq.

226. During a short stay, in July 1816 at Malvern Wells, in Worcestershire, I observed, in climbing one of the hills, a long bare place, which ran diagonally across a smooth grass walk, which had been made for the accommodation of those who visited the wells.

This bare place or path was entirely filled with ants, which were running backwards and forwards, apparently very busy in search of food. The path seemed to be between nine and ten feet in length, and about two inches in breadth, and terminated at the lower extremity in a bed of nettles and long grass; and none of the ants deviated at all from the path till they reached this point, when they separated, and went different ways. Those which returned with food in their mouths deposited it in the nest, which was at the other end.

I observed many of them returning from the nest with something in their mouths, which, upon closer inspection, I found to be their young, which they were taking out, for the purpose, as I concluded, of exposing them to the air and sun. When they had proceeded about one-third of the way down the path, they deposited their charge upon the grass, and returned to the nest, in all probability to fetch more of their young.

I watched several of the ants one by one from the nest, and found that they went an immense way in search of food. I kept my eye upon one in particular for some time, and at length saw it take up a dead fly, with which it was returning to the nest; but when it had proceeded about halfway up the path it was overtaken by another ant, which seemed also to be returning, but which had not been so successful as that whose motions I had been observing: a contest instantly ensued, in which the one that had made the attack succeeded in getting possession of the dead fly, which it carried triumphantly to the nest, while the other returned in search of something else, ashamed to enter the nest without contributing to the general stock.

Upon examining the nest closer, I observed several of the ants that appeared to be wandering beyond the nest, a circumstance which I had not before noticed. I followed them with my eye, and found that there was another path, formed by them amongst the loose stones and sand of the hill; and, upon ascending a little higher, I found it was as much thronged with them as the path below.

I traced them for about 250 or 300 yards, when, to my great surprise, I discovered an immense nest of about fourteen yards in circumference, in which I beheld such myriads of these little creatures that my eyes were actually dazzled with looking at them. The nest was composed of small bits of dry grass, bark of trees, fern leaves, &c. all of them cut into little shreds of about one quarter of an inch in length. The entrances into it were innumerable, and thronged with the busy tribe. Wishing to ascertain the depth of the nest, I thrust my stick into it, and found that, for about a foot and a half, it was composed of these dry leaves, &c.; and upon turning this up I saw all the young and food deposited amongst the small loose stones of which that part of the hill was composed. I did not dare to remain long near the nest, for I found mysely entirely covered from head to foot in the space of two minutes. The next morning I found the breach which I had made the night before completely repaired, and also a dead mole which I had thrown into the nest entirely consumed. I endeavoured to find if there were any other paths which led from the nest, but I could not discover any. There were a great number of ant-hills, made by the *Formica rubra*, or red ant, all around this nest, some within ten or twelve feet; but the ants of both species seemed to keep quite distinct, and never to interfere with each other. I brought several of the ants home with me; and, upon examination, they appear to me to be the *Formica herculanea*, or horse-ant, of Linnæus; but I do not conceive they are peculiar to that part of the country in which I then was."

Mr. Humboldt informs us that ants abound to such a degree near Valencia, that their excavations resemble subterraneous canals, which are filled with water in the time of the rains, and become very dangerous to the buildings.

Arabian Horses.

227. These animals stand unrivalled, throughout the world for fleetness, docility, and beauty. The dearest, as well as the scarcest, are those of the race of *Oœl-Nagdy*. These are brought from Bassora: they are beautiful, gentle, very swift, of a dark bay colour, or more frequently a dapple-grey. They are very intelligent, and extraordinary instances are recorded of their attachment to their masters. Accordingly, they frequently bring as much as eight thousand piastres, (equal to eighteen hundred pounds sterling;) and, on a recent occasion, a mare of this breed was sold at St. Jean d'Acre for the sum of fifteen thousand piastres.

The second race, that of *Guelfé*, is brought from Yémen. It is patient, indefatigable, extremely gentle, and fetches as high a price as four thousand piastres.

The horses of the race of *Secläony*, are brought from the eastern part of the desert; and are not quite so dear.

The race of *Oœl-Mefki* is superb, but less capable of enduring fatigue. These horses are highly prized by the rich Turks of Damascus, and are purchased in the deserts adjacent to that city. They are usually sold at about three thousand piastres.

The race of *Oæl-Sabi* resembles the latter, but is inferior; its price varying from twelve hundred to two thousand piastses.

Lastly, the horses of the race of *Oæl-Treïdi*, are handsome, but often restive; and are less intelligent, as well as less intrepid, than those of the other races. Their usual price is from nine hundred to a thousand piastres.

Beaver Villages in Hudson's Bay.

228. In Beaver Creek, Hays Island, Hudson's Bay, there are three dams made by the beavers with great art and dexterity, two on one side the beaver-house, and another beyond, on the other side. The first is about a mile off the house, and reaches across almost from one bank-edge to the other, running high up the shore, and is about 57 feet in length. The second dam is about a quarter of a mile from the beaver-house, and is 84 feet long. The third dam about 300 yards beyond the house, is different from the other two, which are circular in the middle, and have a cut to vent the water; but this is in a strait line, and has no cut to let the water off.

The beaver house is so situated as to be surrounded about three parts with water, the other part joining to the land; It is round with an oval dome at the top: the height above the water eight feet, about 40 feet in diameter, and in circumference about 120. The bottom part of the house is earth or soil, with pieces of wood laid in it of about three inches circumference; then a parcel of poplar sticks laid with one end in the house, and the other slanting a long way under water: then a layer of earth or soil again; then poplar sticks and these layers of earth, the poplar sticks not exceeding eighteen inches in height; and quite from them to the summit of the house there are soil, stones, and small sticks, all artfully put together, as in the upper part of the dams; and the whole covered with sods, long grass growing thereon, and on the upper part willows. The house is built so that the outermost part of it does not stand further out into the creek than the edge of the shore; but what brings the water so much round it (except the creek in front) is, that the house being built of the earth and soil close to where it stands, the taking that soil has made two trenches, one on each side, which are in the broadest part nine feet, narrowing as they approach the bank, and eighteen feet long, receiving the water of the creek. The house is tight, and hard put together, requiring an ax to break into it, and when the frost is set in, almost impenetrable.

From the house there were several paths into the wood, the track of which much resembles that of a common foot-path; the use of which path is to draw down out of the wood the sticks or trees which they have there got, either for food or building; and they bite off all the twigs, or pieces of willow and poplar which grow across, or in the way, to make a free passage.

This house was said to have no beavers in it, by reason they had been disturbed; for when once beavers are disturbed, they immediately quit that habitation. The Indians know in the summer season, whether the beavers inhabit a house or not, by looking on the stems of the poplar, the upper part or branches of which have been bit off, and seeing whether the marks of their teeth are fresh or not; for it is with their fore-teeth, which are shaped like those of a rabbit, that they cut down all their wood, and the pieces, where cut, look as if they had been cut by a cooper's gouge: If the marks are fresh, they then know that the house is not forsaken. The Indians also know by the mark which their teeth leave, what kind of beavers there are in such house, their age and number; at a birth they have from two to five, and not more, and breed annually.

The Indians sometimes shoot them, which they do by getting to the leeward of the beavers; and they must make use of some dexterity, for the beaver is an extremely shy animal, sharp at hearing, and of a quick scent; and the opportunities they have of shooting them is at such times as the beavers are at work, or when ashore to feed on the poplar. They work in the morning and evening, when every thing is quiet; while at work, they will stop all of a sudden, and listen if they can hear any thing, and if they do, jump into the water immediately, continue there a short time, and then rise at a distance. They are sometimes taken by traps: the bait being poplar-sticks, laid in a path, and near to the water; which, if the beavers begin to feed on, a large log of wood falls on their necks. At the setting of these traps, the Indians first wash their hands, and use all possible means that the poplar with which they set these traps, shall not smell of their hands, for then the beaver would not come near it.

The beaver comes not upon the land in the winter, but then they attack him in his house, and his skin is reckoned in the highest perfection about Christmas. To take the beaver in winter, they break the ice at a distance from the house in two places, the one behind the other. They then take away the broken ice with a kind of rake, for otherwise the loose ice would hinder them from seeing where to place their stakes.

The nets are of a large mesh, and sometimes eight or ten fathoms in length, either made of twine, or of deer-skin cut into thongs; and with these stakes and nets, the house is inclosed, and the beaver cannot escape by water. When the nets and stakes are fixed, they then go to breaking up the house, and when broke up turn in their dog; the beaver, frightened, immediately quits the house, the entrance to which is always by a hole from the water, never by the land-way. The beaver taking the water is deceived by the meshes of the net, and is soon entangled in it; and as soon as entangled, gives notice by the ringing of a bell, which is fixed to the top of the net. The Indians, who are not masters of a bell, watch if the water rises, and if it does, they are as expeditious as possible in getting out the beaver, and in putting it down again. Sometimes the beavers will return, when they find they cannot get further than the net, to the house, and there be taken, and knocked on the head; first making a great moan, according to common report like that of a human creature, sitting on their hinder parts, rubbing their fore-paws together, and tears running from their eyes.

When the Indians take a house of them, they generally leave two to breed. The beaver is a valuable booty to the Indians, both as excellent food, cloathing, and a commodity to trade with. The Indians make use of the teeth of beavers to sharpen their knives, or any other iron tools.

As to the inside of the beaver-houses, the commonly received opinion of their building several stories in them, one above another, is fictitious: the floor is high, resembling an oven. The beavers have one spot near the water's edge, where they lie upon dry grass, ready to dive into the water on hearing a noise. In another part there is the poplar (which they provide in the summer against the winter) the greater length of which lies out of the house in the water, which they pull in as they want it. In another part is their dung, or soil, which they are under the necessity of laying there; for if they voided it in the water, and especially in frosty weather, their entrance would soon be choked up.

What the beaver feeds on is only the bark and rind of the poplar, not the wood, they also feed on a weed which grows at the bottom of the water. Their flesh, in appearance, is like mutton, but as to the taste it has a great resemblance to pork. It is a strong meat, and very satiating. The most delicate part is the tail.

The beavers are remarkably affectionate one to the other: two of them were caught when about six weeks old, and brought alive to one of the Hudson's Bay factories, where they were preserved by pieces of poplar put into water, and a place was made for them to lodge in; they throve for nearly two months when, one night, one of them, by a fall from the parapet at the top of the factory, was killed; the other was perceived the next day to moan, and to eat nothing: and so he continued to do for four days, when he died.

The Camel.

229. This animal is a native and inhabitant of the vast deserts of Africa and Asia; and no creature seems so peculiarly fitted to the climate in which it exists.

Designing the camel to dwell in a country where he can find little nourishment, nature has been sparing of her materials in the whole of his formation. She has not bestowed on him the plump fleshiness of the ox, horse, or elephant; but limiting herself to what is strictly necessary, she has given him a small head without ears, at the end of a long neck without flesh. She has taken from his legs and thighs every muscle not immediately requisite for motion; and in short, has bestowed on his withered body only the vessels and tendons necessary to connect its form together. She has furnished him with a strong jaw, that he may grind the hardest aliments; but lest he should consume too much, she has straitened his stomach, and obliged him to chew the cud. She has lined his foot with a lump of flesh, which sliding in the mud, and being in no way adapted to climbing, fits him only for a dry level, and sandy soil like that of Arabia. She has evidently destined him likewise to slavery, by refusing him every sort of defence against his enemies. Destitute of the horns of the bull, the hoof of the horse, the tooth of the elephant, and the swiftness of the stag, how can the camel resist or avoid the attacks of the lion, the tiger, and even the wolf? To preserve the species, therefore, nature has concealed him in the depths of the vast deserts, where the want of vegetables can attract no game, and whence the want of game repels every voracious animal.

Become domestic, the camel has rendered habitable the most barren soil the world contains. He alone supplies all his master's wants. The milk of the camel nourishes the family of the Arabs, under the varied forms of curd, cheese, and butter; and they often feed upon his flesh. Slippers and harness are made of his skin, and tents and clothing of his hair. Heavy burdens are transported by his means: and when the earth denies forage to the horse, so valuable to the Bedouin or wandering Arab, the she camel supplies that deficiency by her milk, at no other cost, for so many advantages, than a few stalks of brambles or wormwood, and pounded date. So great is the importance of the camel to the deserts, that were they deprived of that useful animal, they must infallibly lose every inhabitant.

There are, in the east, four species of camels, the first of which is, the Arab camel: it carries the heaviest burdens, has one hunch only on the back, and is provided with but little hair. The second is the dromedary, or swift camel, called by the Arabs *hedjyn:* it is smaller, and more slightly built than the former, and also one hunch only. Several of these animals will trot at such a rate as to be able to perform twenty leagues between sun-rise and sun-set. This species is very scarce, and proportionally dear. The Turisman camel constitutes the third species; and of this the caravans of Persia, and those which proceed from Aleppo to Smyrna and Constantinople, are composed. It has but one hunch, its legs are shorter and thicker than those of the Arab camel, it is of a darker colour, and the hair, which flows from its neck, reaches the ground. The fourth species is the Bactrian camel, it is provided with two hunches, is in common use in China and Tartary, but is scarce in Lower Asia.

The Kaiman Alligator.

230. The Kaiman, a species of the alligator, or crocodile, is found in the southern rivers of the United States of America. Some of the kaimans are of so monstrous a size as to exceed five yards in length. They devour all living animals that they can catch. They are fond of the flesh of hogs and dogs. When basking on the shore they keep their huge mouths wide open till they are filled with musquitoes, flies, and other insects, when they suddenly shut their jaws and swallow their prey. They are great destroyers of fish in the rivers and creeks, which they catch with the same address.

Eight or ten of these lie at the river or creek, whilst others go to a distance up the river, and chase the fish downward, by which means none of any bigness escape them. They are said, however, to remain torpid during the winter, in dens which they find in the banks of the rivers, having previously swallowed a large number of pine knots, which form their only sustenance till the period of their revival or waking. The kaiman seldom touches a man, however near it may lie to him. It constantly flies when on land; but in the water it is fiercer, and has been known to bite off the leg of a person bathing: it more frequently attacks dogs. Sometimes, when hounds, in pursuit of a stag, swim through the water, the kaimans seize both the hounds and deer, and pull them down to the bottom, without their ever appearing again. The scales with which they are coated render them invulnerable, unless the wound be inflicted in the interstices of the scales, or at the extremities.

Account of the great Sea Serpent seen on the Coasts of North America, in 1817.

231. In the month of August, 1817, it being currently reported, on various authorities, that an animal of very singular appearance had been recently and repeatedly seen in the harbour of Gloucester, Cape Ann, thirty miles from Boston, the Linnæan Society of New England, in a meeting at Boston, on the 18th of August, appointed the Hon. John Davis, Jacob Bigelow, M.D. and Francis C. Gray, Esq. a committee, to collect evidence with regard to the existence and appearance of such an animal.

Accordingly on the 19th of August, the committee wrote to the Hon. Lonson Nash, of Gloucester, requesting him to examine upon oath, some of the inhabitants of that town upon the subject. And the sum of the testimonies received was this.

First Deposition.

232. Amos Story, of Gloucester, in the county of Essex, Mariner, deposed, that on the 10th day of August, 1817, he saw a strange marine animal, like a serpent, at the southward and eastward of Ten Pound Island, in the harbour of Gloucester.

It was noon when he first saw the animal and that it continued in sight for an hour and a half. Story was sitting on the shore about twenty rods from the animal, whose head appeared shaped like the head of a sea turtle, and he carried it from ten to twelve inches above the surface of the water. At that distance it appeared larger than the head of any dog. From the back part of his head to the next part of him that was visible, was from three to four feet. He moved very rapidly through the water, a mile in two or at most in three minutes. On this day, Story did not see more than ten or twelve feet of his body. He likewise saw, what I believe to be the same animal, on the 23rd of August, 1817, in the morning, about seven o'clock. He then lay perfectly still, extended on the water, and Story judged that he saw fifty feet of it at least.

He had a good telescope both days, and continued looking at him about half an hour, and he remained still and in the same position. Neither his head nor tail were visible. His colour appeared to be a dark brown, and when the sun shone upon him, the reflection was very bright. Story thought his body was about the size of a man's.

Second Deposition.

233. Solomon Allen, of Gloucester, Shipmaster, deposed, that on the 12th, 13th, and 14th of August, 1817, he saw a strange marine animal, which he believed to be a serpent, in the harbour of Gloucester. This animal was from eighty to ninety feet in length, and about the size of a half barrel, apparently having joints from his head to his tail. Allen was about 150 yards from him. The head formed something like a rattle-snake, but nearly as large as that of a horse. When he moved on the surface of the water, his motions were slow; at times playing about in circles, and sometimes moving nearly straight forward.

When he disappeared, he sunk apparently, directly down, and would re-appear at the distance of 200 yards in one minute. His colour was a dark brown. Allen was in a boat on the twelfth inst. and went round the animal several times, within 150 yards. On the thirteenth inst. he saw it nearly all the day, from the shore, and most of the time it was from 150 to 300 yards from Allen. On the fourteenth he saw it but one. The joints or bunches of the fish appeared about eight or ten inches above the surface of the water, and were about fifty in number. He moved to the right and left, and appeared rough and scaly. He appeared to avoid Allen's boat, though he afterwards saw it make towards a boat in which were some other people. When Allen looked at him from the shore with a glass, at about 200 yards distance, his mouth appeared to be open about ten inches. At times he carried his head about ten feet above the surface of the water; then again he would carry the top of his head just on the surface. He turned short and quick, and the first part of the curve that he made in turning resembled the link of a chain; but when his head came parallel with his tail, his head and tail appeared near together.

Third Deposition.

234. I, Epes Eilary, of Gloucester, Shipmaster, depose, that on the 14th day of August, 1817, I saw a sea animal, that I thought to be a serpent, in the harbour in said Gloucester.

I was on an eminence, near low-water mark, and about thirty feet above the level of the sea, when I saw him. I should judge that he was about 150 fathoms from me. I saw the upper part of his head, and about forty feet of the animal. He appeared to me to have joints, about the size of a two-gallon keg. I was looking at him with a spy-glass, when I saw him open his mouth, which appeared like that of a serpent; the top of his head appeared flat. His motion when he turned was quick. I did not count the number of bunches, but they appeared about six inches above the surface of the water. Its sinuosities were vertical. He appeared to be amusing himself, though there were several boats not far from him.

Fourth Deposition.

235. I, William H. Foster, of Gloucester, merchant, depose, that on the 14th day of August, 1817, I first saw an uncommon sea snimal, that I believe to have been a serpent, in the harbour in said Gloucester.

His head was above the surface of the water, perhaps ten inches, and he made but little progress. He was apparently shaded with light colours. He afterwards went in different directions, leaving on the surface of the water, marks like those made by skaiting on the ice. Then he would move in a straight line west, and would almost in an instant change his course to east, bringing his head, as near as I could judge to where his tail was: raising himself as he turned, six or eight inches out of the water, and shewing a body at least forty feet in length. On the seventeenth instant, I again saw him. He came into the harbour, occasionally exhibiting parts of his body, which appeared like rings or bunches. As he drew near, and when opposite to me, there rose from his head or the most forward part of him, a prong or spear about twelve inches in height, and six inches in circumference at the bottom, and running to a small point. It appeared smooth and of a brown colour, I thought it appeared to notice objects. It moved at the rate of a mile in a minute.

Fifth Deposition.

236. I, Matthew Gaffney, of Gloucester, Ship carpenter, depose, that on the 14th day of August, 1817, between the hours of four and five o'clock in the afternoon, I saw a strange marine animal, resembling a serpent, in the harbour in said Gloucester. I was in a boat, and was within thirty feet of him.

His head appeared full as large as a four-gallon keg; his body as large as a barrel, and his length that I saw, I should judge forty feet at least. The top of his head was of a dark colour, and the under part of his head appeared nearly white, as did also several feet of his belly, that I saw. I fired at him, I had a good gun, and took good aim at his head, and I think I must have hit him. He turned towards us immediately, but sunk down and went directly under our boat, and made his appearance at about 100 yards from where he sunk. He did not turn down like a fish, but appeared to settle directly down, like a rock. My gun carries a ball of eighteen to the pound; and I suppose there is no person in the town more accustomed to shooting than I am. I have seen the same animal at several other times, but never had so good a view of him as on this day. His motion was vertical like the caterpillar.

He moved at the rate of a mile in two, or at most in three minutes. He turns quick and short, and the first part of the curve thathe makes in turning, is in the form of the staple; but his head seems to approach rapidly towards his body, his head and tail moving in opposite directions, and, when his head and tail come parallel, they appear almost to touch each other. He did not appear shy after I fired at him; but continued playing as before.

Sixth Deposition.

237. I, James Mansfield, of Gloucester, merchant, depose, that I saw a strange creature of enormous length, resembling a serpent. I think this was on the 15th of August, 1817.

He was from forty to sixty feet in length, extended on the surface of the water, with his head above, about a foot. He remained in this position but a short time, and he started off very quick. I saw bunches on his back about a foot in height, when he lay extended on the water. His colour appeared to me black, or very dark. It was a little before six o'clock, P.M. when I saw him, he moved a mile in five or six minutes. The serpent was about one hundred and eighty yards from the shore where I stood. And his head appeared about the size of a crown of a hat.

Seventh Deposition.

238. I, John Johnston, jun. of Gloucester, of the age of seventeen years, depose, that, on the evening of the seventeenth day of August, 1817, between the hours of eight and nine o'clock, while passing from the shore in a boat, to a vessel lying in the harbour in said Gloucester, I saw a strange marine animal, that I believe to be a serpent, lying extended on the surface of the water.

His length was fifty feet at least, and he appeared straight, exhibiting no protuberances. Captain John Corliss, and George Marble were in the boat with me. We were within two oars' length of him, when we first discovered him, and were rowing directly for him. We immediately rowed from him, and at first concluded to pass by his tail; but, fearing we might strike it with the boat; concluding to pass around his head, which we did, by altering our course. He remained in the same position, till we lost sight of him. We approached so near to him that I believe I could have reached him with my oar. There was not sufficient light to enable me to describe the animal.

Eighth Deposition.

239. I, William B. Pearson, of Gloucester, merchant, depose, that I have several times seen a strange marine animal that I believe to be a serpent of great size.

I have had a view of him only once, and this was on the 18th of August, 1817. I was in a sail boat, and when off Webber's Cove, I saw something coming out, we hove-to, not doubting but that it was the same creature that had been seen several times in the harbour. The serpent passed out under the stern of our boat towards Ten-Pound Island; then he stood in towards us again, and crossed our bow. We immediately exclaimed, 'here is the snake!' From what I saw of him, I should say, that he was seventy feet in length. I distinctly saw bunches on his back, and once he raised his head out of the water. The top of his head appeared flat. His colour was a dark brown. I saw him at this time about two minutes. His motion was vertical. His velocity at this time was not great; though, at times, I have seen him move with great velocity,—I should say at the rate of a mile in three minutes, and perhaps faster. His size I judged to be about that of half a barrel. I saw Mr. Gaffney fire at him, at about the distance of thirty yards. I thought he hit him, and afterwards he appeared more shy. He turned very short, and appeared as active as the eel, when compared to his size. I thought that I saw his eye at one time, and it was dark and sharp. I saw ten or twelve distinct bunches out of the water at one time; bnt I saw none towards what I thought to be his tail.

Ninth Deposition.

240. I, Sewell Toppan, master of the schooner Laura, depose, that on Thursday morning, the 28th day of August, at about nine o'clock, A.M. at about two miles east of the eastern point of Cape Ann, being becalmed,

I saw a singular kind of animal or fish, which I had never before seen, passing by our quarter, at a distance of about forty feet, standing along shore. I saw a part of the animal or fish ten or fifteen feet from the head downwards, including the head; the head appeared to be of the size of a ten gallon keg, and six inches above the surface of the water. It was of a dark colour. I saw no tongue, but heard William Somerby and Robert Bragg, my two men, who were with me, call out, "look at his tongue." The motion of its head was sideways, but that of the body up and down. His motion was much more rapid than that of Whales, or any other fish, I have ever seen; he left a very long wake behind him; he did not alter his course in consequence of being so near the vessel. I have been at sea many years and never saw any fish that had the least resemblance to this animal. Judging from what I saw out of the water, I should suppose the body was about the size of a half barrel in circumference.

Tenth Deposition.

241. I, Robert Bragg, of Newbury-port, mariner, of the schooner Laura, of Newbury-port, (Sewell Toppan, master,) testify: That on Thursday last, about ten o'clock, A.M. coming in said schooner, bound from Newbury-port to Boston, off Eastern point, (Cape Ann), about a mile and a half from the shore,

I being on deck, the vessel being becalmed, looking at the windward, I saw something break the water, and coming very fast towards us. I mentioned it to the man at the helm, William Somerby: the animal came about 28 or 30 feet from us, between the vessel and the shore, and passed very swiftly by us; he left a very long wake behind him. About six inches in height of his body and head were out of water, and, as I should judge, about fourteen or fifteen feet in length. He had a head like a serpent, rather larger than his body, and rather blunt; did not see his eyes; when astern of the vessel about thirty feet, he threw out his tongue, about two feet in length; the end of it appeared to me to resemble a fisherman's harpoon; he raised his tongue, several times perpendicularly, or nearly so, and let it fall again. He was in sight about ten minutes. I think he moved at the rate of twelve or fourteen miles an hour; he was of a dark chocolate colour, and from what appeared out of water, I should suppose he was about two and a half feet in circumference; he made no noise; his back and body appeared smooth; a small bunch on each side of his head, just above his eyes; he did not appear to be at all disturbed by the vessel; his course was in the direction of the salt Islands; his motion was much swifter than any whale that I have ever seen, and I have seen many; did not observe any teeth; his motion was very steady, a little up and down.

Another Deposition.

242. I, William Somerby, of the schooner Laura, testify and say: That on Thursday last, about ten o'clock, A.M. as I was coming in said schooner from Newbury-port, bound to Boston, off Brace's Cove, a little eastward of Eastern Point (Cape Ann), about two miles from land, the sea was calm, I was at the helm, the serpent form passed swiftly by us —the nearest distance I should judge to be between thirty and forty feet; the upper part of his back and head was above water; the length that appeared was twelve or fifteen feet; his head was like a serpent's, tapering off to a point.

He threw out his tongue a number of times, extending about two feet from his jaws, the end of it resembled a harpoon: he threw his tongue backwards several times over his head, and let it fall again. I saw one of his eyes as he passed; it appeared very bright, and about the size of an ox. The colour of all that appeared was very dark, almost black. He did not appear to take any notice of the vessel, and made no noise. The motion of this animal was much swifter than that of any whale. The motion of the body was rising and falling as he advanced, the head moderately vibrating from side to side. The colour of his tongue was a light brown.

Deposition, proving that the same Serpent, or one of the same Species, was seen in 1815.

243. I, Elkanah Finney, of Plymouth, in the county of Plymouth, mariner, testify and say: that, about the twentieth of June 1815, being at work near the sea shore in Plymouth, at a place called Warren's Cove, where the beach joins the main land; my son, a boy, came from the shore and informed me of an unusual appearance on the surface of the sea in the Cove.

I paid little attention to his story at first; but, as he persisted in saying that he had seen something very remarkable, I looked towards the Cove, where I saw something which appeared to the naked eye to be drift sea weed. I then viewed it through a perspective glass, and was satisfied that it was some aquatic animal, with the form, motion, and appearance of which I had been hitherto unacquainted. It was about a quarter of a mile from the shore, and was moving with great rapidity to the northward. It then appeared to be about thirty feet in length; the animal went about half a mile to the northward, then turned about, and, while turning, displayed a greater length than I had before seen; I supposed at least an hundred feet. It then came towards me, in a southerly direction, very rapidly, until he was in a line with me, when he stopped, and layed entirely still on the surface of the water. I then had a good view of him through my glass, at the distance of a quarter of a mile: his appearance in this situation was like a string of buoys. I saw perhaps thirty or forty of these protuberances or bunches, which were about the size of a barrel. The head appeared to be about six or eight feet long; and, where it was connected with the body, was a little larger than the body. His head tapered off to the size of a horse's head. I could not discern any mouth. But what I supposed to be his under jaw, had a white stripe extending the whole length of the head, just above the water. While he lay in this situation, he appeared to be about a hundred or a hundred and twenty feet long. The body appeared to be of an uniform size. I saw no part of the animal which I supposed to be a tail: I therefore thought he did not discover to me his whole length. His colour was a deep brown or black. I could not discover any eyes, mane, gills, or breathing holes. I did not see any fins or legs. The animal did not utter any sound, and it did not appear to notice any thing. It remained still and motionless for five minutes or more. The wind was light, with a clear sky, and the water quite smooth. He then moved to the southward; but not with so rapid a motion as I had observed before: he was soon out of my sight. The next morning I rose very early to discover him. There was a fresh breeze from the south, which subsided about eight o'clock. It then became quite calm, when I again saw the animal about a mile to the northward of my house. He did not display so great a length as the night before, perhaps not more than twenty or thirty feet. He often disappeared, and was gone five or ten minutes under water. I thought he was diving or fishing for his food. He remained in nearly the same situation, and thus employed for two hours. I then saw him moving off, in a north-east direction, towards the light-house. His quickest motion was very rapid: I should suppose at the rate of fifteen or twenty miles an hour. Mackerel, manhaden, herring, and other bait fish, abound in the Cove where the animal was seen.

Letter to Judge Davis, President of the Linnæan Society, stating former Appearances of the same Serpent.

Dear Sir, *Bath, September* 17, 1817.

244. I make no apology for communicating to you the following statements, in reference to the sea serpent of our coasts.

They consist of extracts from some MS. notes on the District of Maine, which I have been in the habit of making ever since I have resided in the country.

"June 28th, 1809.—The Rev. Mr. Abraham Cummings," who has navigated his own boat among the islands, &c. informs me, "that in Penobscot Bay, has been occasionally seen, within these thirty years, a sea serpent, supposed to be about sixty feet in length, and of the size of a sloop's mast. He saw him in company with his wife and daughter, and a young lady of Belfast, Martha Spring; and judged he was about three times the length of his boat, which is twenty-three feet. When he was seen this time, he appeared not to notice the boat, though he was distant as nearly as could be ascertained, but about fifteen rods. Mr. Cummings observes, that the British saw him in their expedition to Bagaduse; that the inhabitants of Fox and Long Islands have seen such an animal; and that a Mr. Crocket saw two of them together, about twenty-two years since. When he was seen by the inhabitants of Fox Island, two persons were together at both times. People also of Mount Desert have seen him. One of those which were seen by Mr. Crocket, was smaller than that seen by Mr. Cummings; and their motion in the sea appeared to be a perpendicular winding, and not horizontal. The British supposed the length of that which they saw, to be three hundred feet, but this Mr. Cummings imagines to be an exaggeration. The Rev. Alden Bradford, of Wiscasset, now secretary of the commonwealth, inquired of Mr. Cummings, whether the appearance might not be produced by a number of porpoises following each other in a train; but Mr. Cummings asserts, that the animal held his head out of water about five feet, till he got out to sea; for, when seen, he was going out of the Bay, and

Mr. Cummings was ascending it. The colour was a bluish green about the head and neck, but the water rippled so much over his body that it was not possible to determine its tint. The shape of the head was like that of a common snake, flattened, and about the size of a pail. He was then seen approaching, passing, and departing. The weather was calm, and it was the month of August; in which month it is said the serpent makes his appearance on the coast."

"August 23, 1809.—Mr. Charles Shaw, (then of Bath, now an attorney at Boston) informed me, that a Captain Lillis, with whom he had sailed, told him that he had seen off the coast a very singular fish, which was about forty feet long. It held its head erect, had no mane, and looked like an ordinary serpent.

About two years after hearing this, while on a journey to India Old Town, I had an opportunity to make further inquiry, and find in my journal the following entry:

"September 10, 1811.—A Mr. Staples of Prospect, was told by a Mr. Miller, of one of the islands of the bay, that he had seen the great sea serpent, and 'it was as big as a sloop's boom, and about sixty or seventy feet long.' Mr. Staples told me also, that about 1780, as a schooner was lying at the mouth of the river, or in the bay, one of these enormous creatures leaped over it between the masts; that the men ran into the hold for fright, and that the weight of the serpent sank the vessel 'one streak,' or plank. The schooner was about eighteen tons.

About four weeks after the foregoing depositions had been received, a serpent of remarkable appearance was brought from Gloucester to Boston, and exhibited as the progeny of the great serpent. It had been killed upon the sea-shore by some labouring people of Cape Ann. Captain Beach, jun. the possessor, very liberally submitted it to examination, and permitted an opening to be made in the side for the inspection of its internal structure.

CHAPTER X.

ASTRONOMICAL SCIENCE.

SECTION I.

THE SOLAR SYSTEM.

245. THIS science derives its name from αστηρ STAR, and νομος, LAW or RULE. And it is divided into two parts. The first treats of the motions, magnitudes, and periods of the revolution of the heavenly bodies: the second investigates the causes and laws by which those motions are regulated. The former is called PURE or PLAIN ASTRONOMY; the latter PHYSICAL ASTRONOMY.

The heavenly bodies which we shall chiefly notice, are the sun, the planets, comets, and stars. The phenomena of the celestial world will form a separate article, of which we shall afterwards treat.

246. The SUN, the source of light and heat, is by far the most considerable object that we behold suspended in space by the power of the Almighty Creator of the universe. And this splendid globe governs all the planetary motions, in as much as it is poised in or near the common centre of gravity, around which all the planets of the solar system are annually whirled.

Illus. The sun is 337,086 times greater than the earth; it is surrounded by an atmosphere; it is sometimes covered with spots, and some of these spots have been observed four or five times as large as the earth. The observation of these spots shews that the sun moves in its axis, and 25½ days is the duration of its entire sidereal rotation. The sun and planets seem to have a motion towards the constellation of Hercules.

Obs. When we consider the sun as the fountain of light, that illuminates the world, and causes our earth to produce every thing desirable for man, may we not consider it also as an eminent, large, and lucid planet, evidently the primary one of our system; Mercury, Venus, the Earth, and all the others being its secondaries? And considering its solidity, its atmosphere and diversified surface, its rotation on its axis, and all the circumstances attending this glorious globe, may we not conclude that it is inhabited, like the other planets, by beings whose organs are adapted to the physical properties of the sun. This seems to be a more pleasing and agreeable way of making the tour of creation, than joining issue with fanciful poets, who have pronounced it the abode of blessed spirits; or closing with the chilling doctrines of angry moralists, who have fancied it the fittest residence for the punishment or purgation of the wicked from off the earth.

SECTION II.

THE PLANETS.

247. THERE are eleven planets belonging to our system. Six of these have been recognised from time immemorial: namely, Mercury, Venus, the Earth, Mars, Jupiter, and Saturn. But the remaining five, invisible to the naked eye, have lately been discovered by the help of the telescope; and are therefore called telescopic planets: namely,

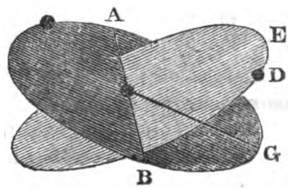
Uranus, discovered by	Dr. Herschel,	March 13, 1781.
Ceres	M. Piazzi,	January 1, 1801.
Pallas,	M. Olbers,	March 28, 1802.
Juno,	M. Harding,	Septem. 1, 1803.
Vesta,	M. Olbers,	March 29, 1807.

248. All these planets revolve round the sun, as the centre of motion: and in performing their revolutions they follow the laws of planetary motion discovered by Kepler; and confirmed by subsequent observations. These laws are,

249. The orbit of each planet is an ellipse; of which the sun occupies one of the foci.

That focus is called the *lower focus.* If we suppose the plane of the earth's orbit, which passes through the centre of the sun, to be extended in every direction, as far as the fixed stars, it will mark out a great circle among them, which is the *ecliptic;* and with this the situations of the orbits of all the other planets are compared.

The planes of the orbits of all the other planets must necessarily pass through the centre of the sun, but if extended as far as the fixed stars, they form circles different from each other, as also from the ecliptic ; one part of each orbit, is on the north, and the other on the south side of the ecliptic. Therefore the orbit of each planet cuts the ecliptic in two opposite points, as A, B, which are called the *nodes* of that particular planet; and the nodes of one planet cut the ecliptic in planes different from the nodes of another planet.



The line A B is called the *line of the nodes.*

The *ascending node* is that where the planet passes from the south to the north side of the ecliptic. The angle E ● G is the inclination of the planes of the two orbits to each other.

The *descending node* that where the planet passes from the north to the south side of the ecliptic.

Perigee, when the sun and moon are nearest the earth: *apogee*, when at their greatest distance.

The extremity of the major axis of this ellipse, nearest the sun, is called the perihelion; the opposite extremity of the same axis is call the aphelion. The line, which joins these two points, is called the line of the apsides. The radius vector is an imaginary line drawn from the centre of the sun to the centre of the planet, in any part of its orbit.

The velocity of a planet in its orbit is always greatest at its perihelion. This velocity diminishes as the radius vector increases; till the planet arrives at its aphelion, when its motion is the slowest. It then increases in an inverse manner, till the plant arrives again at its perihelion.

250. The areas, described about the sun by the radius vector of the planet, are proportional to the times employed in describing them.

These laws are sufficient for determining the motion of the planets round the sun; but it is necessary to know, for each of these planets, seven quantities; which are called the elements of their elliptical motion. The first five of these elements relate to the motion in an ellipse; the last two relate to the position of the orbit; since the planets do not all move in the same plane.

1. The duration of a sidereal revolution of the planet.
2. Half the major axis of the orbit; or the mean distance of the planet from the sun.
3. The eccentricity of the orbit; whence we deduce the greatest equation of the centre.
4. The mean longitude of the planet at a given epoch.
5. The mean longitude of the perihelion.
6. The longitude of the nodes at a given epoch.
7. The inclination of the orbit to the ecliptic.

251. The following tables from La Place's *Exposition,* present all these elements for the first moment of the present century; that is to say, for that point of time at midnight which separated the 31st of December 1800, and the 1st of January 1801; mean time at Paris.—[The observatory at Paris is in north latitude 48° 50′ 14″, and in longitude 9′ 21″ east from Greenwich observatory.]

1. *Duration of a Sidereal Revolution.*

	Days.		Days.
Mercury	87·92925804	Ceres	1681·53900000
Venus	224·70082399	Pallas	1681·70900000
Earth	365·25638350	Jupiter	4332·59630760
Mars	686·97961860	Saturn	10758·96984000
Vesta	1335·20500000	Uranus	30688·71268720
Juno	1590·99800000		

2. *Mean Distance from the Sun.*

Mercury	·3870381	Ceres	2·7674060
Venus	·7233323	Pallas	2·7675920
Earth	1·0000000	Jupiter	5·2027911
Mars	1·5236935	Saturn	9·5387705
Vesta	2·3730000	Uranus	19·1833050
Juno	2·6671630		

3. *Ratio of the Eccentricity to half the Major Axis.*

Mercury	·20551494	Ceres	·07834860
Venus	·00685298	Pallas	·24538400
Earth	·01685318	Jupiter	·04817840
Mars	·09322000	Saturn	·05616830
Vesta	·09322000	Uranus	·04667030
Juno	·25404400		

4. *Mean Longitude, January* 1, 1801.

	Days.		Days.
Mercury	182° 15647	Ceres	294° 16820
Venus	11° 93672	Pallas	280° 68580
Earth	111° 28179	Jupiter	124° 67781
Mars	71° 24145	Saturn	150° 38010
Vesta	297° 12990	Uranus	197° 54244
Juno	322° 79380		

5. *Mean Longitude of the Perihelion.*

Mercury	82° 6256	Ceres	162° 9565
Venus	142° 9077	Pallas	134° 7040
Earth	110° 5571	Jupiter	12° 3812
Mars	369° 3407	Saturn	99° 0549
Vesta	277° 4630	Uranus	185° 9574
Juno	59° 2349		

6. *Longitude of the ascending Node.*

Mercury	51° 0651	Ceres	89° 9083
Venus	83° 1972	Pallas	191° 7148
Earth	0° 0000	Jupiter	109° 3624
Mars	53° 3605	Saturn	124° 3662
Vesta	114° 4630	Uranus	80° 9488
Juno	190° 1228		

7. *Inclination of the Orbit to the Ecliptic.*

Mercury	7° 78058	Ceres	11° 80680
Venus	3° 76936	Pallas	38° 46540
Earth	0° 00000	Jupiter	1° 46034
Mars	2° 05663	Saturn	2° 77102
Vesta	7° 94010	Uranus	0° 85990
Juno	14° 50860		

The examination of the first two tables will shew us that the duration of the revolutions of the planets increases with their mean distance from the sun. Whence Kepler discovered his third fundamental law; namely,

252. The squares of the times of the revolutions of the planets are to each other as the cubes of their mean distances.

Obs. The ellipses, which the planets describe, however, are not unalterable. Their major axes appear to be always the same; but their eccentricities, the positions of their perihelion and nodes, together with the inclination of their orbits to the ecliptic, seem to vary in a course of years.

Mercury ☿.

253. MERCURY, the planet nearest the sun, is yet thirty-six millions of miles distant from that luminary; and the proportion of light and heat which it receives from the Sun is about 6·68 times greater than on the earth. Its diameter is 3123 miles.

This planet performs his sidereal revolution * in 87^d 23^h 15′ 43″,9; and his mean synodical † revolution is about 116 days.

The rotation of this planet on its axis is performed in 1^d 0^h 5′ 28″,3.

And the elongation or angular distance of this planet from the sun varies from 16° 12′, to 28° 48′.

Mercury changes his phases like the moon ‡, according to his various positions with regard to the earth and sun; but this appearance is seen only with a telescope.

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* The sidereal revolution of a planet is the time that planet takes in passing from any fixed star, till its return to that star again.

† The synodic revolution of a planet is the time between two conjunctions, or two oppositions of the same planet and the sun.

‡ Phases denote the various appearances of the moon at different ages, being at one time crescent, then a semicircle, then gibbous, and lastly, full: after which the same phases return again in the same order.

When therefore it is said Mercury and Venus change phases like the moon; the meaning is that they are sometimes crescent, then a semicircle, then gibbous. Mars partakes of these phases in some measure, being at times gibbous.

The same must also have place in a less degree with the other superior planets.

The same term is also used to denote the Sun or Moon when eclipsed.

Venus, ♀.

254. VENUS, the next planet above Mercury, is computed to be sixty-eight millions of miles from the sun, and by moving at the rate of seventy-six thousand miles an hour, she completes her annual revolution in 224 days and 16 hours, 49′ 11″ and a half, and her synodical revolution is about 548 days. Her diameter is seven thousand seven hundred miles, or nearly the size of our earth, and her diurnal rotation on her axis, is performed in 23 hours 21 minutes and 7″.

Venus is often seen by the unassisted eye in broad day-light. The proportion of light and heat received by this planet from the sun is 1·91 times greater than the earth. And it is surrounded with an atmosphere the refractive powers of which differ very little from ours.

Like Mercury, it sometimes passes over the sun's face, and its transit has been applied to one of the most important problems in astronomy, as by it the true distances of the planets from the sun have been determined. These transits take place in the months of June and December. The 1st will be on the 8th December 1874.

When Venus is to the west of the sun, it rises before the sun, and is called a morning star; this appearance continues about 290 days together; when this planet is to the east of the sun, it sets after the sun, and is called an evening star for about the same period of 290 days. Venus appears the brightest of the planets: it has a considerable atmosphere, and some astronomers assert that they have discovered mountains on its surface.

The Earth, ⊕.

255. The EARTH which we inhabit is the planet next in order; hence we say Mercury and Venus are inferior; but all the planets which are further from the sun than the earth is, are superior planets. The earth is 93 millions of miles from the sun; it performs its sidereal revolution in $365^d\ 6^h\ 9'\ 11''\ 5$; and it passes from the one tropic, to the same again is only $365^d\ 5^h\ 48'\ 51''\ 6$.

The axis of the earth is inclined to the plane of the ecliptic in an angle of 23° 27′ 57″,0; but this angle decreases at the rate of 52″,1 in a century. Yet this variation of the angle is confined within certain limits; and cannot exceed 2° 42′.

The annual intersection of the equator with the ecliptic is not always in the same point: but is retrograde, or contrary to the order of the signs. Consequently the equinoxial points appear to move forward to the ecliptic; thence this phenomenon is called the precession of the eqinoxes. The quantity of this annual change is 50″,1; or 1° 23′ 30″ in a century. A complete revolution is performed in 25868 years.

The sidereal day, or the time employed by the earth in revolving on its axis, is always the same. Its diurnal rotation has not varied the hundredth part of a second, since the time of Hipparchus. If the mean astronomical, or civil, day be taken equal to 24 hours, the duration of the sidereal day will be 23^h 56′ 4″,1

The astronomical, or civil, day is constantly changing. This variation arises from two causes; 1. The unequal motion of the earth in its orbit; 2. The obliquity of that orbit to the plane of the equator.

Obs. The mean and apparent solar days are never equal, except when the sun's daily motion in right ascension is 59′ 8″. This is the case about April 16th, June 16th, September 1st, and December 25th: on these days the difference vanishes, or nearly so. It is at its greatest about November 1st, when it is 16′ 16″.

The astronomical year is divided into four parts, which are determined by the two equinoxes and the two solstices. The interval between the vernal and autumnal equinoxes is (on account of the eccentricity of the earth's orbit, and its unequal velocity therein) near eight days longer than the interval between the autumnal and vernal equinoxes. These intervals are, at present, nearly as follows:

	d. h. m.	*d. h. m.*
From the spring equinox to the summer solstice	..92 21 45	=185 35 20
From the summer solstice to the autumnal equinox	..93 13 35	
From the autumnal equinox to the winter solstice...........	..89 16 47	=178 18 29
From the winter solstice to the spring equinox	..89 1 42	
		7 16 51

Light takes 8′ 13″,3 to come from the sun to the earth. But in this interval the earth has moved 20″,2 in its orbit. This motion of the earth produces an optical illusion in the light which comes from the stars; and which Bradley calls the aberration of light.

The figure of the earth is that of an oblate spheroid; the axis of the poles being to the diameter of the equator as 331 to 332. The mean diameter of the earth is about 7916 miles; its equatorial diameter is 7924 miles.

As a necessary consequence from this circumstance, the degrees of latitude increase in length as we recede from the equator to the poles. But different meridians, under the same latitnde, present different results. The general fact, however, is well ascertained.

The centrifugal force is greater at the equator than at the poles: in consequence of which bodies lose part of their weight by being taken towards the equator. If the gravity of a body at the equator be represented by unity, its gravity at the poles will be increased by ·00569. A pendulum, therefore, which vibrates seconds in the higher latitudes, must be shortened at the equator in order to render the oscillations isochronous.

Obs. A pendulum 39·197 inches long will swing seconds at the poles; but, in order that it may swing seconds at the equator it must be reduced to 39·027 inches.

The centrifugal force at the equator is nearly $\frac{1}{289}$th of gravity. If the rotation of the earth were 17 times more rapid, the centrifugal force would be equal to that of gravity, and bodies at the equator would not have any weight.

The earth is surrounded by a rare elastic and heterogeneous fluid called the atmosphere; and out of 100 parts, 97 are azotic gas and 21 oxygen gas. But of this we shall treat hereafter.

Mars, ♂.

256. Mars first above the earth's orbit is easily known by his red and fiery appearance. He performs his sidereal revolution in $686^d\ 23^h\ 30'\ 39''$ or in 1,881 julian years; and his mean synodical revolution is about 780 days or in about 2,135 years.

His mean distance from the sun is above 142 millions of miles.

The rotation on his axis is performed in $1^d\ 0^h\ 39'\ 21'',3$; and his mean diameter is 4398 miles or rather more than one half the size of our earth.

This planet has a very dense but moderate atmosphere, and he is not attended by any satellite. And the proportion of light and heat received by him from the sun is ·43, that received by the earth being considered as unity.

Mars changes his phases, in the same manner as the moon does from her first to her third quarter, according to his various positions with respect to the earth and sun.

Jupiter, ♃.

257. Jupiter is, next to Venus, the most brilliant of all the planets, whom he sometimes however surpasses in brightness. He performs his sidereal revolution in $4332^d\ 14^h\ 18'\ 41'',0$; or in 11·862 Julian years. But this period is subject to some inequalities. He performs his mean synodical revolution in about 399 days.

His mean distance from the sun is above 485 millions of miles.

The rotation on his axis is performed in $9^h\ 55'\ 49'',7$: and his axis forms an angle of $86°\ 54'\ 30'',0$ with the plane of the ecliptic.

His mean diameter is equal to 91522 miles: consequently he is about 11½ times as large as our earth The axis of his poles is to his equatorial diameter as ·9287 to 1, or as 13 to 14.

The proportion of light and heat, received from the sun, is ·037: that received by the earth being considered as unity.

He is surrounded by faint substances called zones or belts; which are supposed to be parts of his atmosphere. And he is accompanied by four satellites.

A body, which weighs one pound at the equatorial surface of the earth, would, if removed to the surface of Jupiter, weigh 2·281 pounds.

As seen from the earth, the motion of Jupiter appears sometimes to be retrograde. The mean arc which he describes in this case is about $9°\ 54'$: and its mean duration is about 121 days. This retrogradation commences, or finishes, when the planet is not more distant than $115°\ 12'$ from the sun.

His mean apparent equatorial diameter is $38'',2$: it is greatest when in opposition, at which time it is equal to $47'',6$.

Saturn, ♄.

258. Saturn performs his sidereal revolution in $10758\ 23^h\ 16°\ 34'',2$; or in 29·456 Julian years. But this period is subject to some inequalities. His mean synodical revolution is performed in about 378 days.

His mean distance from the sun is above 890 millions of miles.

The rotation on his axis is performed in $10^h\ 16'\ 19'',2$: and the axis is inclined in an angle of 58° 41′ to the plane of the ecliptic.

His mean diameter is 76068 miles: consequently he is nearly ten times as large as our earth. The axis of his poles is to his equatorial diameter as 11 to 12.

The proportion of light and heat received from the sun is ·0011; that received by the earth being considered as unity.

Saturn is sometimes marked by zones or belts; which are probably obscurations in his atmosphere. And he is accompanied by seven satellites.

The most singular phenomenon, however, attending this planet, is the double ring with which he is surrounded.

This ring, which is very thin and broad, is inclined to the plane of the ecliptic in an angle of 31° 19′ 12″,0; and revolves from west to east, in a period of $10^h\ 29'\ 16'',8$, about an axis perpendicular to its plane and passing through the centre of the planet.

The breadth of the ring is nearly equal to its distance from the surface of Saturn: that is about ⅓ of the diameter of the planet.

The surface of the ring is separated in the middle by a black concentric band, which divides it into two distinct rings.

The edge of this ring, being very thin, sometimes disappears: and, as this edge will present itself to the sun twice in each revolution of the planet, it is obvious that the disappearance of the ring will occur about once in 15 years; but under circumstances oftentimes very different.

The intersection of the ring and the ecliptic is in 5^s 20° and 11^s 20°; consequently, when Saturn is in either of those signs, his ring will be invisible to us. On the contrary, when he is in 2^s 20° or 8^s 20°, we may see it to most advantage. This was the case towards the end of the year 1811.

Uranus.

259. Uranus was discovered by Dr. Herschel, March 13, 1781, who gave it the name of the *Georgium Sidus*. It performs its sidereal revolution in

30688d 17h 6′ 16″,2; or, in about 84 Julian years: and it is probably situated at the confines of the planetary system.

Its distance from the sun is upwards of 1800 millions of miles: and its apparent diameter is scarcely 3″,9.

Six satellites accompany this planet; which move in orbits nearly perpendicular to the plane of the elliptic.

Vesta.

260. The next planet in our system is Vesta, for the knowledge of which we are indebted to Dr. Olbers of Bremen, being first discovered by him March 29th, 1807. Its distance from the sun is about 223 millions of miles,and its annual revolution in its orbit is performed in 3 years 7¼ months. But neither has its diameter, nor the duration of its diurnal rotation, been yet ascertained.

Juno ⚵.

261. Juno, the next in order, is another new planet; discovered by Mr. Harding, at the observatory at Lilienthol, near Bremen, Sept 1st, 1804. The mean distance of this planet from the sun is estimated at two hundred and fifty-three millions of miles, and its annual revolution is performed in 4 years, 4 months, and 6 days; but its diameter, and the time of its revolving on its axis are unknown.

Pallas ⚴.

262. The next superior planet above Juno, is Pallas, which was first observed by Dr. Olbers, March 8th, 1812: the mean distance of which, from the sun, is reckoned to be about two hundred and sixty-three millions of miles, and its revolution in its orbit is made in about 4 years, 7 months, and 10 days; but like the two former, its diameter and diurnal rotation have not as yet been ascertained.

Ceres ⚳.

263. Ceres is the next higher planet, in our system; which was first discovered by Piazzi, of Palermo, Jan. 1st, 1801. Its mean distance is nearly the same as that of Pallas, and consequently its annual revolution is performed in nearly the same time.

SECTION III.

SATELLITES.

264. The number of satellites in our system, at present known, is eighteen: namely, the Moon which revolves round the earth; four which belong to Jupiter, seven to Saturn, and six to Uranus. The moon is the only one visible to the naked eye.

They all move round their primary planets, as their centre, by the same laws as those primary ones move round the sun: namely,

I. The orbit of each satellite is an ellipse, of which the primary planet occupies one of the foci.

II. The areas, described about the primary planet, by the radius vector of the satellite, are proportional to the times employed in describing them.

III. The squares of the times of the revolutions of the satellites, round their respective primary planets are to each other as the cubes of their mean distances from the primary.

Moon.

265. The motions of the moon are exceedingly eccentric and irregular. She performs her mean sidereal revolution in $27^d\ 7^h\ 43'\ 11'',5$. But this period is variable: and a comparison of the modern observations with the ancient proves incon-

testably an acceleration in her mean motion. Her mean tropical revolution is $27^{d}\ 7^{h}\ 43'\ 4'',7$; and her mean synodical revolution is $29^{d}\ 12^{h}\ 44'\ 2'',8$.

Her mean distance from the earth is 29.982175 times the diameter of the terrestrial equator; or above 237000 miles.

Her orbit is inclined to the plane of the ecliptic in an angle of 5° 9′; but this inclination is variable. The greatest inequality, which sometimes extend to 8′ 47″,1, is proportional to the co-sine of the angle on which the inequality of the nodes depends.

Her orbit, at the commencement of the present century, crossed the ecliptic in 0^{s} 15° 55′ 26″,3; but the place of her nodes is variable. They have a retrogade motion, and make a sidereal revolution in about 18·6 Julian years. A synodical revolution of the nodes is performed in $346^{d}\ 14^{h}\ 52'\ 43'',6$. The motion of the nodes is subject also to a secular inequality, dependent on the acceleration of the moon's mean motion.

The rotation of the moon on her axis is equal and uniform; and it is performed in the same time as the tropical revolution in her orbit, whence she always presents nearly the same face to the earth. But, as the motion of the moon in her orbit, is periodically variable, we sometimes see more of her eastern edge, and sometimes more of her western edge. This appearance is called the libration of the moon in longitude.

The axis of the moon is inclined to the plane of the ecliptic in an angle of 88° 29′ 49″. In consequence of this position of the moon, her poles alternately become visible to, and obscured from us: and this phenomenon is called her libration in latitude.

There is also another optical deception arising from the moon being seen from the surface of the earth, instead of the centre. This appearance is called her diurnal libration.

The figure of the moon is that of an oblate spheroid like the earth. Her mean diameter is in the proportion to that of the earth, as 5823 to 21332; or as 1 to 3·665. Whence her mean diameter will be about 2160 miles. But the apparent diameter of the moon varies according to her distance from the earth. When nearest to us it is 33′ 31″,1; and at her greatest distance it is 29′ 21″,5. Hence her mean apparent diameter is 31′ 26″,5.

The phases of the moon are caused by the reflection of the sun's light; and depend on the relative positions of the sun, the earth, and the moon.

An eclipse of the moon can take place only at the time of her opposition to the sun; and is caused by her passing through the shadow of the earth. That shadow is 3½ times longer than the distance between the moon and the earth: and its breadth, where it is traversed by the moon, is about 2⅔ times greater than the diameter of the moon. The breadth of the earth's shadow, where it is traversed by the moon, is equal to the difference between the semi-diameter of the sun, and the sum of the horizontal parallaxes of the sun and moon.

The moon cannot be eclipsed, however, if her distance from the place of her node, at the time of her opposition, exceeds 13° 21′; but if it is within 7° 47, there will certainly be an eclipse. The duration of the eclipse will depend on the apparent diameter of the moon, and on the breadth of the shadow at the point where she traverses it.

The sun cannot be eclipsed unless the moon be in conjunction; and then only when the centres of the sun and moon are in the same straight line with the eye of the spectator on the earth, in such case, if the apparent diameter of the moon be greater than that of the sun, the eclipse will be total; but, if it be less, it will be annular. Partial eclipses, however, may arise; as in the case of lunar eclipse.

The sun cannot be totally obscured for a longer period of time than four minutes; but the moon may be hid from our view for a much longer period.

The number of eclipses in a year cannot be less than two, nor more than seven.

Eclipses generally return in the same order and magnitude at the end of 223 lunations.

The atmosphere of the moon, if it has any, must be more rare than that which we can produce with our best air-pumps.

The light of the moon is 300000 times more weak than that of the sun. Its rays, collected by the aid of powerful glasses, do not produce any sensible effect on the thermometer.

The refraction of the rays of light, at the surface of our earth, must be at least 1000 times greater than the surface of the moon.

Volcanoes and mountains are discovered on her surface, by the aid of the telescope.

A body projected from the surface of the moon, with a momentum that would cause it to proceed at the rate of about 8200 feet in the first second of time, and whose direction should be in a line which at that moment passed through the centre of the earth and moon, would not fall again to the surface of the moon, but would become a satellite to the earth. Its primitive impulse might, indeed, be such as to cause it even to precipitate to the earth. The stones, which have fallen from the air, may be accounted for in this manner.

Satellites of Jupiter.

266. By the aid of the telescope we may discover four satellites revolving round Jupiter. The sidereal revolutions of these bodies are given in the following table: together with their mean distances from Jupiter, the semi-diameter of that planet's equator being considered as unity; and likewise their masses, compared with Jupiter considered also as unity.

Satellite.	Sidereal Revolution.		Mean Distauce.	Mass.
I.	1d 18h 27′ 33″,5	1d 769137788148	5·812964	·0000173281
II.	3 13 13 42 ,0	3 551181017849	9 248679	·0000232355
III.	7 3 42 33 ,4	7 154552783970	14·752401	·0000884972
IV.	16 16 31 49 ,7	16 688769707084	25·946860	·0000426591

The satellites of Jupiter are liable to be eclipsed by passing through his shadow; and on the other hand, they are frequently seen to pass over his disk, and eclipse a portion of his surface. This happens to the first and second satellite, at every revolution; the third very rarely escapes in each revolution; but the fourth (on account of its great distance and inclination) is seldom obscured.

These eclipses are of great utility in enabling us to determine the longitude of places, by their observation; and they likewise exhibit some curious phænomena with respect to light.

From the singular analogy, above alluded to, it follows that (for a great number of years at least) the first three satellities cannot be eclipsed at the same time: for in the simultaneous eclipses of the second and third, the first will always be in conjunction with Jupiter, and *vice versâ*.

Satellites of Saturn.

267. Seven satellites may be seen by means of the telescope, to revolve about Saturn; the elements of which are but little known, on account of their

great distance. The following table will show the duration of their sidereal revolutions, and their mean distances in semi-diameters of Saturn.

Satellite.	Sidereal Revolution.		Mean Distance.
I.	0d 22h 37 30″,1	0 94271	3·080
II.	1 8 53 8 ,7	1 37024	3·952
III.	1 21 18 25 ,9	1 88780	4·893
IV.	2 17 44 51 ,1	2 73948	6·268
V.	4 12 25 11 ,1	4 51749	8·754
VI.	15 22 41 13 ,9	15 94530	20·295
VII.	79 7 54 37 ,4	79 32960	59·154

Obs. The orbit of the first six satellites appear to be in the plane of Saturn's ring: whilst the seventh varies from it very sensibly.

Satellites of Uranus.

268. Six Satellities revolve round Uranus; which, together with their primary, can be discovered only by the telescope. The following table will shew their sidereal revolutions, and mean distances in semi-diameters of the primary.

Satellite.	Sidereal Revolution.		Mean Distance.
I.	5d 21h 25′ 20″,6	5d 8926	13·120
II.	8 16 57 47 ,5	8 7068	17·022
III.	10 23 3 59 ,0	10 9611	19·845
IV.	13 10 56 29 ,8	13 4559	22·752
V.	38 1 48 0 ,0	38 0750	45·507
VI.	107 16 39 56 ,2	407 6944	91·008

Obs. All these satellites move in a plane which is nearly perpendicular to the plane of the planet's orbit, and contrary to the order of the signs!

SECTION VI.

OF COMETS.

269. COMETS are certain dark or opaque bodies, like the planets, and move round the sun, but in very eccentric orbits, being sometimes so far from him, that their cold must be excessive, and sometimes so near him that their heat must be so intense, as would prove altogether intolerable to an inhabitant of this earth; and would even destroy, or at least vitrify, the earth itself.

Sir Isaac Newton computed the heat of the comet that appeared in the year 1680, when nearest the sun, to be two thousand times hotter than red hot iron, and that, being thus heated, it must retain its heat till it comes round again, although its period should be more than twenty thousand years; it is computed to be only five hundred and seventy-five.

It is believed that there are at least twenty-one comets belonging to our system, moving in different directions. All those which have been observed, have moved through the etherial regions and the orbits of the planets, without suffering the least sensible resistance in their motions, which sufficiently proves that the planets do not move in solid orbits.

Of all the comets, the periods of three only are known with any degree of certainty, being found to return at intervals of 75, 129, and 575 years: and of these, that which appeared in 1680 is the most remarkable.

This comet, at its greatest distance, is about eleven thousand two hundred millions of miles from the sun, while its least distance from the centre of that luminary is about four hundred and ninety thousand miles. In that part of its orbit which is nearest the sun, it flies with the amazing velocity of eight hundred and eighty thousand miles in an hour; and the sun, as seen from it, appears one hundred degrees in breadth, and consequently forty thousand times as large as he appears to us. The tail of this comet was at least an hundred millions of miles long; and that of 1812 was thirty millions of miles long.

Our earth was out of the way when this comet last passed near her orbit; but it requires a more perfect notion of the motion of the comet to be able to judge if it will always pass by us with so little effect. The comet, in one part of its orbit, approaches very near to the orbit of our earth; so that, in some revolution, it may approach near enough to have very considerable if not fatal effects upon it.

One of the comets was expected to return in 1789, but it has not yet appeared.

Comets are always attended with long transparent trains or tails, issuing from that side of them which is turned away from the sun.

Comets were formerly supposed to be prodigies or portents, and to foretel some great event or revolution, such as the fall of empires, or the death of some eminent and distinguished personage; but they are now known to have no more connection with the civil or political affairs of the world, than any other of the heavenly bodies.

The comet of 1811-12.

270. The chief particulars relating to this splendid comet may be arranged as follows.

1. *The planetary body in the head of a comet* as seen with the naked eye, presents a luminous appearance not unlike a star; but that within its densest light there was an extremely small bright point, entirely distinct from the surrounding glare, and which by geometrical calculation was found to be from 428 miles to 120 thousand miles in diameter.

2. *The eccentricity, colour, and atmosphere of the planetary body.* The bright point was not in the middle of the head, but more or less eccentric at different times; and the colour of the planetary disk was of a pale, ruddy tint, like that of such equally small stars, as are inclined to red; and Dr. Herschel infers that it was visible by rays emitted from its own body, yet that since the central illumination, which, moderately magnified, was pretty uniform, became diluted into a gradual decrease from the middle towards the outside, the comet was surrounded by a transparent and elastic atmosphere. And this atmosphere was more than 507 thousand miles in diameter,

3. *The tail of the comet.* The most brilliant phenomenon that accompanies a comet is the stream of light which we call the tail.

The greatest real length of the tail was 100 millions of miles, and the real breadth was 15 millions of miles. This tail had a curved shape or flexure, and in its general appearance it seemed to be inclosed at the sides by two streams or branches arising from the sides of the head. And the tail of the comet being, on Nov. 9, very near the milky way, the appearance of the one compared to that of the other, in places where no stars could be seen in the milky way, was perfectly alike. And that the tail is a hollow cone we may infer from the fact that the inside showed a comparative darkness, whereas had it been a cone of solid luminous matter, the brilliancy would have increased toward the centre, instead of diminishing.

SECTION V.

OF THE FIXED STARS.

271. THE *fixed stars* comprehend all the other heavenly bodies, except the sun, planets, and comets. They are distinguished by the naked eye from the planets, by being less bright and luminous, and by continually exhibiting that appearance which we call the twinkling of the stars. (*Obs.* 4. p. 46.) This arises from their being so apparently small, that the interposition of the least body, of which there are many constantly floating in the air, deprives us of the sight of them. When the interposed body changes its place, we again see the star; and this succession being perpetual, occasions the twinkling.

But a more remarkable property of the fixed stars, and that from which they have obtained their name, is their never changing their situation, with regard to each other, as the planets change their situations.

The stars which are nearest to us seem largest, and are therefore called of the first magnitude. Those of the second magnitude appear less; and so proceeding on to the sixth magnitude, which includes all the fixed stars that are visible without a telescope.

Of the number of fixed Stars.

272. As to their number, though in a clear winter's night, without moonshine, they seem to be innumerable, which is owing to their strong sparkling, and our looking at them in a confused manner, yet when the whole firmament is divided, as it has been done by the ancients, into signs and constellations, the number that can be seen at a time, by the naked eye, is not above a thousand.

Since the introduction of telescopes indeed, the number of the fixed stars has been justly considered as immense; because the greater perfection we arrive at in our glasses, the the more stars always appear to us. Mr. Flamstead, late royal astronomer at Greenwich, has given us a catalogue of about three thousand stars. Halley observed three hundred and fifty more in the southern hemisphere. And Dr. Herschel thinks he has seen stars 42,000 times as far off as Sirius. In one instance a cluster of five thousand stars, in a mass, were barely visible in the forty-foot telescope, and consequently must have been eleven trillions of miles off.

273. The constellations of the Zodiac, with their characters:

			Stars.
	Spring.	*Northern Signs.*	
♈	Aries	*Ram*	66
♉	Taurus	*Bull*	141
♊	Gemini	*Twins*	85
	Summer.	*Northern Signs.*	
♋	Cancer	*Crab*	83
♌	Leo	*Lion*	95
♍	Virgo	*Virgin*	110
	Autumn.	*Southern Signs.*	
♎	Libra	*Scales*	51
♏	Scorpio	*Scorpion*	44
♐	Sagittarius	*Archer*	69
	Winter.	*Southern Signs.*	
♑	Capricornus	*Goat*	51
♒	Aquarius	*Water-bearer*	108
♓	Pisces	*Fishes*	103
	Total number of stars in the zodiac		1016

Obs. It is not easy to say why the ancient astronomers affixed such images as the Ram, the Bull, &c. to the twelve signs of the zodiac. There is great reason, however, to suppose that they were placed as hieroglyphics of the seasons of the year, alluding to the annual course of the sun.

Thus Aries, Taurus, and Gemini, represent *March*, *April*, and *May*, the spring quarter of the year, when *lambs*, *calves*, and *goats* (the latter generally bringing forth *twin kids*) are produced.

Cancer, the *Crab*, which creeps both ways, represents the increase and decrease of the sun's declination, to and from the summer solstice, in June.

Leo, the *Lion*, intimates the raging heat of the sun in July, which the ancients compared to the furious nature of that fierce animal.

Virgo, the *Virgin*, with a spike or ear of corn in her hand, properly represents August, when the harvest of the earth is ripe.

Libra, the *Balance*, is displayed in September, to intimate that the days, at the autumnal equinox, are equal in all parts of the globe.

Scorpio, the *Scorpion*, a noxious animal, is placed as the hieroglyphic of October, because, at that season, diseases of various kinds too often rage.

Sagittarius, the *Archer*, marks November as the proper time for hunting.

Capricornus, the *Goat*, by its climbing up the rocks, is placed as an emblem of December, when the sun, at the winter solstice, begins to ascend again towards the equinoctial.

Aquarius, the *Water-bearer*, with his urn, represents January, when rains are frequent.

Pisces, the *Fishes*, are emblems of the fishing season, which began in the Nile during the month of February.

The names of the twelve signs are contained in the following verses:—

The *ram*, the *bull*, the *heavenly twins*,
And next the *crab*, the *lion* shines,
The *virgin*, and the *scales*;
The *scorpion*, *archer*, and the *goat*,
The man that holds the *water-pot*,
And *fish* with glittering tails.

Northern Constellations.

274. The Little Bear, the Great Bear, the Dragon, the Greyhound, Bootes, and Mons. Menelaus: Cephoeus, Berenice's Hair, Charles's Heart, the Northern Crown, Hercules, and Cerberus: The Harp, the Swan, the Fox, the Goose, the Lizard, Cassiopeia, and Perseus; Andromeda, the Great Triangle, the Little Triangle, Auriga, Pegasus, the Dolphin, and the Arrow: The Eagle, Serpentarius, the Serpent, Sobieski's Shield, Camelopardus, and the Colt; Antinous, the Lynx, the Little Lion, and Musca.

Southern Constellations.

275. The Whale, the River Eridanus, the Hare, Orion, the Great Dog, and the Little Dog: the Ship Argo, Hydra, the Centaur, the Cup, the Crow, the Wolf, and the Altar: the Southern Crown, the Southern Fish, the Phœnix, the Crane, and the Peacock: Noah's Dove, the Indian, the Bird of Paradise, Charles's Oak, the Southern Triangle, and the Fly or Bee: the Swallow, the Cameleon, the Flying-fish, the American Goose, the Water Serpent, and the Sword Fish.

Obs. Some of the principal stars have particular names given them, as *Aldebaran*, in the *Bull's Eye; Regulus*, or the *Lion's Heart: Arcturus*, in *Bootes; Sirius* in the *Great Dog; Spica*, or the *Ear of Corn*, in *Virgo; Pleiades*, or the *Seven Stars.*

SECTION VI.

ARRANGEMENT OF THE CELESTIAL BODIES IN SPACE, BY DR. HERSCHEL.

276. The construction of the heavens, in which the real place of every celestial object in space is to be determined, can only be delineated with precision, when we have the situation of each heavenly body assigned in three dimensions, which, in the case of the visible universe, may be called length, breadth, and depth; or longitude, latitude, and profundity.

Of the local Situation of the Stars of the Heavens.

277. When we look at the heavens in a clear night, and observe the different lustre of the stars, we are impressed with a certain idea of their different magnitudes; and when our estimation is confined to their appearance only, we shall be justified in saying, for instance, that Arcturus is larger than Aldebaran.

The principle on which the stars are classed is, therefore, entirely founded on their apparent magnitude, or brightness.

Now, as it was thought convenient to arrange all the stars, which in fine weather may be seen by the eye, into seven classes, the brightest were called of the first, and the rest according to their gradually diminishing lustre, of the 2d, 3d, 4th, 5th, 6th, and 7th magnitudes. Then, since it is evident that we cannot mean to affirm that the stars of the 5th, 6th, and 7th magnitudes are really smaller than those of the 1st, 2d, or 3d, we must ascribe the cause of the difference in the apparent magnitudes of the stars to a difference in their relative distances from us; and on account of the great number of stars contained in each class, we must also allow that the stars of each succeeding magnitude, beginning from the first, are, one with another, further from us, than those of the magnitude immediately preceding it.

Of a Standard, by which the relative Arrangement of the Stars may be examined.

278. It is evident, that when we propose to examine how the stars of the heavens are arranged, we ought to have a certain standard of reference; and this I believe may be had by comparing their distribution to a certain properly modified equality of scattering.

Now, the equality I shall here propose, does not require that the stars should be at equal distances from each other; nor is it necessary that all those of the same nominal magnitude should be equally distant from us. It consists in allotting a certain equal portion of space to every star; in consequence of which we may calculate how many stars any given extent of space should contain. This definition of equal scattering agrees so far with observation, that it admits, for instance, Sirius, Arcturus, and Aldebaran to be put into the same class, notwithstanding their very different lustre will not allow us to suppose them to be at equal distances from us; but its chief advantage will be, that instead of the order of magnitudes into which our catalogues have arranged the stars, it will give us an order of distances, which may be used for ascertaining the local distribution of the heavenly bodies in space.

Comparison of the Order of Magnitudes, with the Order of Distances.

279. The catalogue given in the *Philosophical Transactions,* contains 17 stars of the first magni-

tude; but in my figure of the order of the distances their number is 26.

The same catalogue has 57 stars of the second magnitude; but the order of distance admits 98.

On the third magnitude, the catalogue has 206. and the order of distances will admit 218.

The number of the stars of the fourth magnitude, is, by the catalogue, 454, and by the order of distances 386.

By these four classifications of the stars into magnitudes, it appears that, on account of the great difference in the lustre of the brightest stars, many of them have been put back into the second class; and that the same visible excess of light has also occasioned many of the stars of the next degree of brightness to be put into the third class; but the principle of the visibility of the difference in brightness would have less influence with the gradually diminishing lustre of the stars, so that the number of those of the third magnitude would come nearly up to those of the third distance. And as the difference in the light of small stars is less visible than in the large ones, we find that the catalogue has admitted a greater number of stars of the fourth magnitude than the fourth order of distances points out; this may, however, be owing to taking in the stars that were thrown back from the preceding orders; and a remarkable coincidence of numbers seems to confirm the account of the arrangement of the stars into magnitudes. For the total number of the catalogued stars of the 1st, 2d, 3d, and 4th magnitudes, with the addition of the sun, is 735; and the number contained in the whole sphere of the fourth distance is 729.

Of a Criterion for ascertaining the Profundity, or local Situation of Celestial Objects in Space.

280. The statement that, one with another, the faintest stars are at the greatest distance from us, seems to me so forcible, that I believe it may serve for the foundation of an experimental investigation.

It will be admitted, that the light of a star is inversely, as the square of its distance; if therefore we can find a method, by which the degree of light of any given star may be ascertained, its distance will become a subject of calculation. But in order to draw valid consequences from experiments made upon the brightness of different stars, we shall be obliged to admit, that one with another the stars are of a certain physical generic size and brightness, still allowing that all such deviations may exist, as generally take place among individuals belonging to the same species.

With regard to size, or diameter, we are, perhaps, more liable to error; but the extensive catalogue which has already been consulted, contains not less than 14,144 stars of the seven magnitudes that have been adverted to; it may therefore be presumed that any star promiscuously chosen for an experiment, out of such a number, is not likely to differ much from a certain mean size of them all.

At all events it will be certain that those stars, the light of which we can experimentally prove to be $\frac{1}{4}$, $\frac{1}{9}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{36}$, and $\frac{1}{49}$, of the light of any certain star of the first magnitude, must be 2, 3, 4, 5, 6, and 7 times as far from us as the standard star, provided the condition of the stars should come up to the supposed mean state of diameter and lustre of the standard star, and of this, when many equalizations are made, there is at least a great probability in his favour.

Of various experiments I have long ago tried, the equalization of star-light, which about four years ago I began to put into execution, appeared to be the most practicable.

Of ten highly finished mirrors I selected two of an equal diameter, and focal length, and placed them in two similarly fitted-up seven feet telescopes. When they were completely adjusted, I directed them both, with a magnifying power of 118, to the same star, for instance, Arcturus: and upon trial I found the light not only of this, but of every other star to which they were directed, perfectly equal in both telescopes.

In comparing the light of one star with that of another, I laid it down as a principle, that no estimation but that of perfect equality should be admitted; and as the equal action of the instruments was now ascertained, I calculated the diameters of several apertures to be given to one of the telescopes as a standard, so that the other, called the equalizing telescope, might be employed, with all its aperture unconfined, to examine a variety of stars, till one of them was found whose light was equal to that of the star to which the standard telescope was directed *.

This method of equalizing the light of the stars, easy as it may appear, is nevertheless subject to great difficulties; for

* Dr. Herschel preferred the limitation of the light by circular apertures to the method of obtaining it by the approach or recess of two opposite rectangular plates, in order to avoid the inflections which take place in the angles.

as the brightness of a star is affected by its situation, with regard to the ambient light of the heavens, the stars to be equalized should, if possible, be in nearly the same region. When the sun is deep in the horizon, this is, however, not of so much consequence as the altitude of the star to be equalized, which ought to be, as nearly as possible, equal to that of the standard star. At great elevations some difference in the altitudes of the stars to be equalized may be admitted; but if they are far from each other, the circumstance of the equal illumination of the heavens, and the equal clearness of the air must still be attended to.

Of the Extent of Natural Vision.

281. The following equalizations were made in August and December, 1803, and February 1814, and are given as a specimen of the method I have pursued.

Taking Arcturus for the standard of an experiment, I directed the telescope, with one quarter of its light, upon it: while the equalizing telescope, with all its light, was successively set upon such stars as I supposed might be at double the distance of the standard star: which, as Arcturus is a star of the first magnitude, I expected to find among those of the second.

The first I tried was ζ Pegasi, but I found it not quite bright enough,

The light of α Andromedæ, which next I tried, was nearly equalized to that of Arcturus; and, the observation being repeated on a different night, gave it equal.

In order to obtain some other stars, whose light might be equalized by one quarter the light of Arcturus, I tried many different ones; and found among the α Polaris, γ Ursæ, and δ Cassiopeæ. These stars, therefore, may also be put into the class of those whose light is equal to the stars of the second order of the distance of Arcturus.

As the foregoing experiments can only shew that a star of the light of Arcturus might be removed to eight times its distance, and still remain visible to the naked eye as a star of between the fifth and sixth magnitude; it will be proper to take also other stars of the first magnitude, for the original standards.

For instance, if we begin from Capella as the standard star, we may, with ¼ of its light equalize β Auriga, and β Tauri; which stars will, therefore, be of the second order of distances. With ¼ of the light of ζ Tauri: we equalize ζ Tauri and ι Aurigiæ; they will then be of the fourth order. With ¼ of the light ι Aurigiæ, we can equalize e Persei, and H Geminorum,—which will be of the eighth order, And, with $\frac{16}{25}$ of the light of H Geminorum, we equalize *d* Geminorum,—which makes it a star of the tenth order. That is to say, if Capella were successively removed to two, four, eight, and ten times the distance at which it is from us, it would then have the appearance of the stars which have been named.

To find stars of the intermediate orders of distances, the following table gives the proportional light that should be used with the star which is made the standard; for instance, a star of the second order of distance, with $\frac{4}{9}$ of its light, will equalize a star of the third order; $\frac{9}{25}$ of the light of a star of the third order of distances will give one of the fifth order, and so on.

A star of the order of distances.	With the Proportion of its light.	Gives one of the Order of Distances.
1	$\frac{1}{4}$	2
2	$\frac{4}{9}$	3
	$\frac{1}{4}$	4
3	$\frac{9}{25}$	5
	$\frac{1}{4}$	6
4	$\frac{16}{49}$	7
	$\frac{1}{4}$	8
5	$\frac{25}{81}$	9
	$\frac{1}{4}$	10
6	$\frac{36}{121}$	11
	$\frac{1}{4}$	12

But the extent of natural vision is not limited to the light of solitary stars only; the united lustre of a number of them will become visible when the stars themselves cannot be seen. For instance, the milky-way; the bright spot in the sword handle of Perseus; the cluster north of η and H Geminorum; the cluster south of Fl. 6 and 9 Aquilæ; the cluster south of η Hercules, and the cluster north preceding ι Pegasi. But their distances cannot be ascertained by the method of equalizing star-light: their probable situation in space may, however, be deduced from telescopic observations.

To these very faintly visible objects may be added two of a very different nature, namely, the nebulosity in the sword of Orion, and that in the girdle of Andromeda.

Of the Extent of Telescopic Vision.

282. The Equalization of star-light, when carried to a proper degree of accuracy, will do away the cause of error to which the telescopic extent of vision has been unavoidably subject.

We may therefore safely apply this vision to measure the profundity of sidereal objects that are far beyond the reach of the natural eye; but for this purpose the powers of penetrating into space of the telescopes that are to be used must be reduced to what may be called guaging powers; and, as the formula $\frac{\sqrt{x.\overline{A^2-b^2}}}{a}$ gives the whole quantity of the space-penetrating power, a reduction to any inferior power, p may be made by the expression $\sqrt{\frac{p^2a^2}{x}+b^2}=A$; when the aperture is then limited to the calculated value of A, the telescopes will have the required guaging power. Or we may prepare a regular set of apertures to serve for trials, and find the guaging powers they give to the telescope by the original formulæ.

Application of the Extent of Natural and Telescopic Vision to the Probable Arrangement of the Celestial Bodies in space.

283. When the extent of natural and telescopic vision is to be applied to investigate the distance of celestial objects, the result can only have a high degree of probability; for it will then be necessary to admit a certain physical generic size and brightness, of the stars. But, when two hypotheses are proposed to explain a certain phenomenon, that which will most naturally account for it ought to be preferred as being the most probable.

Now, as the different magnitudes of the stars may be ascribed to a physical difference in their size and lustre, and may also be owing to the greater distance of the fainter ones, we cannot think it probable that all those of the 5th, 6th, and 7th magnitude, should be gradually of a smaller physical construction than those of the 1st, 2d, and 3d: but shall on the contrary, be fairly justified in concluding that, in conformity with all the phenomena of vision, the greater faintness of those stars is owing to their greater distance from us.

I proceed now to consider some conclusions that may be drawn from a known extent of natural vision, a very obvious one of which is, that all the visible stars are probably contained within a sphere of the 12th order of distances. Now as on the principle of equal scattering, we should see about 15625 of them, it may be remarked that the stars of the catalogue, including all those of the 7th magnitude, amount to 14144, which agrees sufficiently well with the calculated number: but the next inference is, that if they were equally scattered, there would be 2402 of the 10th, 2906 of the 11th, and 3458 of the 12th order of distances, which added together amount only to 8766, whereas the number of stars of the 6th and 7th magnitudes that must come into these three orders, is not less than 12249, which would indicate that the stars in the higher order of distances are more compressed than they are in the neighbourhood of the sun; but, from astronomical observations, we also know that the stars of the 6th and 7th magnitudes are very sparingly scattered over many of the constellations; and that, consequently, the stars which belong to the 10th, 11th and 12th order of distances, are not only more compressed than those in the neighbourhood of the sun, but that, moreover, their compression in different parts of the heavens must be very unequal.

Of the Construction and Extent of the Milky-Way.

284. Of all the celestial objects consisting of stars not visible to the eye, the milky way is the most striking; its general appearance, without applying a telescope to it, is that of a zone, surrounding our situation in the solar system, in the shape of a succession of differently condensed patches of brightness, intermixed with others of a fainter tinge.

The breadth of the milky-way appears to be very unequal. In a few places it does not exceed five degrees; but, in several constellations, it is extended from ten to sixteen. In its course it runs nearly 120 degrees in a divided clustering stream, of which the two branches between Serpentarius and Antinous are expanded over more than twenty-two degrees.

That the sun is within its plane, may be seen by an observer in the latitude of about 60 degrees; for when at 100 degrees of right ascension, the milky way is in the east; it will, at the same time, be in the west at 280: while in its meridianal situation, it will pass through Cassiopeæ in the Zenith, and through the constellation of the cross in the Nadir.

From this survey of the milky-way by the eye, I shall now proceed to show what appears to be its construction, by applying to it the extent of telescopic vision.

From the Formula which has been given, I calculated a set of apertures, which, by limiting the light of the finder of my seven feet reflector, would reduce its space-penetrating power to the low guaging powers two, three, and four. I then limited, in the same manner, the space-penetrating power of my night-glass, by using calculated apertures, such as would give the guaging powers five, six, seven, and eight. From the space-penetrating power of the seven feet reflector, I obtained, by limitation, the successive guaging powers nine, ten, and upwards to seventeen. And lastly, by limiting the space-penetrating power of my ten feet reflector, I carried the guaging powers from seventeen to twenty-eight.

With a ten feet reflector, reduced to a guaging power of eighteen, I saw a great number of stars: they were of very different magnitudes, and many whitish appearances were so faint, that their consisting of stars remained doubtful. The power nineteen, which next I used, verified the reality of several suspected stars, and increased the lustre of the former ones. With twenty, twenty-two, and twenty-five, the same progressive verifications of suspected stars took place; and those which had been verified by the preceding powers, received subsequent additional illumination. With the whole space-penetrating power of the instrument, which is 28,67, the extremely faint stars in the field of view acquired more light, and many still fainter suspected whitish points, could not be verified for want of a still higher guaging power. The stars which filled the field of view, were of various orders of telescopic magnitudes; and were probably scattered over a space extending from the 204th to the 344th order of distances.

From the greater diameter of the mirror of the forty-feet telescope, we have reason to believe that a review of the milky-way with this instrument would carry the extent of this brilliant arrangement of stars as far into space as its penetrating power can reach.—which would be to the 2300th order of distances; and that it would then probably leave us again in the same uncertainty as the twenty-feet telescope.

Concluding Remarks.

285. What has been said of the extent and condition of the milky-way, in several of my papers on the construction of the heavens, with the addition of the observations contained in this attempt to give a more correct idea of its profundity in space, will nearly contain all the general knowledge we can ever have of this magnificent collection of stars. To enter upon the subject of the contents of the heavens, in the two comparatively vacant spaces on each side adjoining the milky-way, the situation of globular clusters of planetary nebulæ, and of far extended nebulosities, would greatly exceed the compass of this paper; I shall therefore only add one remarkable conclusion, that may be drawn from the experiments which have been made with the guaging powers.

Let a circle, drawn with the radius of the twelfth order of distances, represent a sphere containing every star that can be seen by the naked eye; then, if the breadth of the milky-way were only five degrees, and if its profundity did not exceed the 900th order of distances, the two parallel lines in the figure representing the breadth of the milky-way, will, on each side of the centre of the inclosed circle, extend to more than the 39th order of distances.

From this it follows, that not only our sun, but all the stars we can see with the eye, are deeply immersed in the milky-way, and form a component part of it.

CHAPTER XI.

PHYSICAL ASTRONOMY.

SECTION I.

OF MOTION AND ITS LAWS.

286. MOTION is a simple idea, and therefore admits not of definition: when we say that it is a continual

and successive change of place, we describe it in a periphrasis, by its sensible effects. Or, by another circumlocution, motion may be described as that state of a body which is not consistent with its continuance in the same place; or which it is not, in two successive instants of duration, at the same distance from diverse fixed points in space: this state is opposed to that of rest.

The communication of motion from one body to another, though a fact with which we are well acquainted, we are equally incapable of accounting for. It is, however, of the utmost importance in mechanical philosophy, which is indeed derived from its laws. Moreover, the principle upon which all philosophical discussion proceeds is, that *every change which we observe in the condition of things, is considered by us as an effect indicating the agency characterizing the kind, and measuring the degree, of its cause.*

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

Obs. Whenever, therefore, we use the word *force* or *power*, in a mechanical sense, it is to denote that which causes a change in the state of a body, whether that state be rest or motion.

The investigation of the laws of the planetary bodies must therefore begin with the consideration of motion, carefully noticing every affection, or quality of it, so as to establish marks and measures of every change of which it is susceptible; for these are only marks and measures of the changing forces.

287. From the general principle of philosophical discussion mentioned above, we derive these three axioms.

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

2. *Every change of motion is always proportional to the degree of the moving force by which it is produced, and it is made in the line of direction in which that force is impressed.*

3. *That action and reaction are always equal and contrary; or the mutual actions of two bodies upon*

each other are always equal, and directed to contrary parts.

Of the axioms, the first has respect to the continuance of bodies in a state of repose or of motion, without *any alteration,* except so far as subsequent causes operate; the second assigns the quantity and nature of such alterations; and the third has respect to the mutual circumstances of the patient, that suffers such alteration from any cause, and of the agent producing the alteration.

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

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

288. In considering motion there are several circumstances which must be attended to:

1. The force which impresses the motion;
2. The quantity of matter in the body moved;
3. The velocity and direction of motion;
4. The space passed over in the moving body;
5. The time employed in going over this space;
6. The force with which it strikes another body that may be opposed to it.

289. Every body, by its inertia, resists all change of state; therefore, to put a body in motion, there must be a sufficient cause.

Obs. Every body at rest on the surface of the earth will always continue so, if no external force be impressed upon it to give it motion; and if motion be communicated to it by another body, it will continue to move for ever uniformly, unless it be stopped by an external agent.

These causes are called *motive powers,* and they are either muscular or mechanical; as the action of men and other animals; the force of wind, water, gravity, the pressure of the atmosphere, the elasticity of fluids, springs, and steam.

The change of motion produced in any body is proportional to the force impressed, and in the direction of that force.

290. To every action of one body upon another there is an equal and contrary *re-action:* or the mutual actions of bodies on each other are equal and in contrary directions, and are always to be estimated in the same right line.

291. The *velocity of motion* is estimated by the time occupied in moving over a certain space, or by the space moved over in a certain time. The less the time, and the greater the space moved over, the greater is the velocity; on the contrary, the greater the time, and the less the space moved over, the less is the velocity.

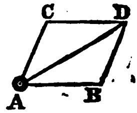
A body in motion must every instant tend to some particular point. It may either tend always to the same point, in which case the motion will be in a straight line; or it may be continually changing the point to which its motion is directed; and this will produce a curvilinear motion.

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

If a body be acted upon by one force only, or by several forces in the same direction, its motion will be in the same direction, in which the moving force or forces act; as the motion of a boat, in smooth water, which a man draws with a rope.

292. *Equable motion* is either simple or compound. *Simple* motion is that which is produced by the action, or impressed force, of one cause. *Compound* motion is that which is produced by two or more conspiring powers; that is, by powers whose directions are neither opposite nor coincident.

If two or more forces differently directed, act upon the same body at the same time, as the body in question cannot obey them all, it will move in a direction somewhat between them.



Illus. Suppose a body A to be acted upon by another body in the direction A B, while at the same time it is impelled by another in the direction A C, then it will move in the direction A D; and if the lines A B, A C, be made of lengths proportionate to the forces, and the lines C D, D B, drawn parallel to them, so as to complete the parallelogram A B, D C, then the line which the body A will describe, will be the diagonal A D; and the length of this line will represent the force with which the body will move.

It is evident that if the body be impelled by equal forces acting at right angles to each other, it will move in the diagonal of a square; but whatever may be the direction, or degree of force by which the two powers act, the above method will always give the direction and force of the moving body.

It follows from this, that if we know the effect which the joint action of two powers have upon a body, and the force and direction of one of them, it is easy to find that of the other. For suppose A D to be the direction and force with which the body moves, and A B to be one of the impelling forces, then, by completing the parallelogram, the other power A C is found.

Instances in nature, of motion produced by several powers acting at the same time, are innumerable. A ship impelled by the wind and tide is one well known: a paper kite acted upon in one direction by the wind, and in another by the string, is another instance.

293. *Accelerated Motion,* is that in which the velocity is continually increasing from the continued action of the motive power. *Uniform accelerated motion* is that in which the velocity increases equally in equal times.

Motion is said to be *retarded,* if its velocity continually decreases; and to be *uniformly retarded,* if its velocity decreases equally in equal times.

If you suppose a body to be put in motion by a single impulse, and, moving uniformly, to receive a new impulse in the same direction, its velocity will be augmented, and it will go on with the augmented velocity.

If at each instant of its motion it receive a new impulse, the velocity will be continually increasing; and if this impulse be always equal, the velocity will be uniformly accelerated.

The regularly increasing velocity with which a body falls to the earth, is an instance of accelerated motion which is caused by the constant action of gravity.

Let us suppose the time of descent of a falling body to be divided by a number of very small equal parts: the impression of gravity, in the first small instant, would make the body descend with a proportionate and uniform velocity; but in the second instant, the body receiving a new impulse from gravity, in addition to the first, would move with twice the velocity as before; in the third instant it would have three times the velocity, and so on.

The velocities of falling bodies are in proportion to the spaces run over, and the space passed over in each instant, increases in arithmetical progression, or as the numbers 1, 3, 5, 7, 9, &c.

It is found by experiment that a body falling from a height, moves at the rate of 16$\frac{1}{12}$ feet in the first second; and as has been shewn above, acquires a velocity of twice that, or 32$\frac{1}{6}$ feet in a second. At the end of the next second, it will have fallen 64$\frac{1}{3}$ feet, the space being as the square of the time: the square of 2 is 4, and 4 times 16$\frac{1}{12}$, is 64$\frac{1}{3}$. By the same rule you may find, that in the third second it will fall 144$\frac{3}{4}$ feet; in the fourth second, 257$\frac{1}{3}$; and so on.

SECTION II.

PLANETARY ATTRACTION.

294. ATTRACTION is understood to signify the tendency that bodies have to approach each other. And it is called the attraction of *cohesion*, the attraction of *gravitation*, &c.

The attraction of GRAVITATION or GRAVITY, is that force by which all the masses of matter tend towards each other, and which they exert at all distances. It is that by which the heavenly bodies are retained in their several places, by their action on each other; and it is also by this, that a stone, when dropped from a height, falls to the surface of the earth.

It is one of the laws of nature, discovered by NEWTON, and now received by all philosophers, that every particle of matter gravitates towards every other particle; this law is the main principle in the *Newtonian Philosophy*. The planets and comets all gravitate towards the sun, and towards each other, as well as the sun towards them, and that in proportion to the quantity of matter in each.

All terrestrial bodies tend towards a point, which is either immediately or very nearly, the centre of the earth; consequently, bodies fall every where perpendicular to its surface, and, therefore, on opposite sides in opposite directions. As it acts upon all bodies in proportion to their quantities of matter, it is this attractive force that constitutes the weight of bodies.

If two bodies which contain equal quantities of matter, were placed at ever so great a distance from one another, and then left at liberty in free space, and if there were no other bodies in the universe to affect them, they would fall equally swift towards each other, and would meet in a point which was half-way between them at first. Or if two bodies, containing unequal quantities of matter, were placed at any distance, and left in the same manner at liberty, they would fall towards one another, with velocities which would be in an inverse proportion to their respective quantities of matter; and moving faster and faster in their mutual approach, would at last meet in a point as much nearer to the place from which the heavier body began to fall, than to the place from which the lighter body began to fall, as the quantity of matter in the former exceeded that in the latter.

All bodies whatever have a certain degree of gravity or weight. Even smoke and vapours possess gravity, but they do not descend, because they are lighter than the air, and are supported by it: the reason of their apparent levity will be fully shewn afterwards.

In all places equi-distant from the centre of the globe, the force of gravity is equal. The earth, however, is not perfectly a sphere, but a spheroid; that is, having its equatorial longer than its polar axis by about thirty-seven miles; hence, the force of gravity is less at the equator than at the poles, because the centrifugal force of the earth at the equator diminishes the gravity: this is proved by the necessity of making the pendulum shorter at the equatorial than in the polar regions. Hence, seconds' pendulums, which in the latitude of London must be 39,2 inches, require to be one-tenth shorter, or 39,1 at the equator.

The force of gravity is greatest at the earth's surface, from whence it decreases both upwards and downwards, but not both ways, in the same proportion; for upwards the force of gravity decreases, as the square of the distance from the centre increases, so that, at a double distance from the centre above the surface, the force would be only one-fourth of what it is at the surface; but below the surface of the earth, the power decreases in such a manner, that its intensity is directly as the distance from the centre, and not as the square of the distance; so that at the distance of half a semi-diameter from the centre, the force would be but half what it is at the surface: at one-third of the semi-diameter the force would be one-third, and so on for any other assumed distances.

Further, gravity and weight may be taken, in particular circumstances, as synonymous terms. We say such a piece of lead weighs a pound, sixteen ounces, but if by any means it could be carried to four thousand miles above the surface of the earth, it would only weigh one-fourth of a pound, or four ounces; and provided it could be removed eight thousand miles above the earth, which is three times the distance from the centre that the surface is, it would weigh only one-ninth of a pound, or $1\frac{7}{9}$ ounces.

Again, since the force of gravity downwards decreases, as the distance from the surface increases, the same weight already described, would weigh at one-half the distance from the centre to the surface, only one half of a pound or eight ounces, and so on for one third, &c.

Hence, a piece of metal, &c. weighing on the surface of the earth, one pound, will

At the centre, weigh	0
1,000 miles from the centre	$\frac{1}{4}$ of a pound
2,000	$\frac{1}{2}$
3,000	$\frac{3}{4}$
4,000	1
8,000	$\frac{1}{4}$
12,000	$\frac{1}{9}$th.

As all bodies gravitate towards the earth, so does the earth gravitate towards all bodies, as well as all bodies to particular parts of the earth; for, by an experiment made by the late Dr. Maskelyne upon the side of the mountain Schehallien, he found the attraction of that mountain sufficient to draw the plumb-line sensibly upon the perpendicular, so that it did not tend to the centre of the earth.

When we speak of attracting powers we do not attempt to explain their nature, or assign their causes. The cause of gravity is totally unknown. Many theories have been invented to account for it, but they have all been mere hypotheses, or conjectures, without any foundation. Having derived general principles, or laws of nature, from phenomena, which is the business of philosophy, we only give a name to those principles, in order to explain other appearances by them.

SECTION III.

LAWS OF THE PLANETARY MOTION.

295. In consequence of the *vis inertiæ* of matter, all motion produced by one force only acting upon a body, must be rectilinear; for it must receive some particular direction from the power that impressed it, and must retain that direction until it is changed by some other power. Whenever, therefore, we see a body moving in a curvilinear direction, we may be certain that it is acted upon by two forces at least; but when one of those two forces ceases to act, the body will move again in a straight line.

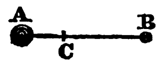
Thus a stone in a sling is moved round by the hand, while it is pulled towards the centre of the circle which it describes by the string; but when the string is let go, the stones flies off in a tangent to the circle.

Every body moved in a circle, hath a tendency to fly off from its centre, which centre is called the *centrifugal force*; and it is opposed to the *centripetal force*, or that which, by drawing bodies to the centre, makes them revolve in a curve. These two forces are called together *central forces*.

296. The centre of gravity of a body, or a system of bodies, is that point about which all the points of the body or system of bodies, do in any situation exactly balance each other.

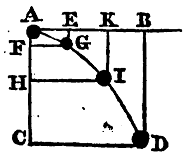
Hence, if a body be suspended or supported by this point, the body will rest in any position into which it is put. Also, whatever supports that point, bears the weight of the whole body; and while it is supported, the body cannot fall. We may, therefore, consider the whole weight of a body, as centred in this point.

The common centre of gravity of two or more bodies, is the point about which they would equiponderate, or rest in any position.



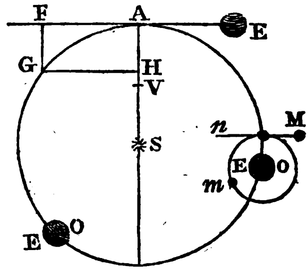
Illus. If the centres of gravity of two or more bodies, A and B, be connected by the right line A B, the distances A C and B C, from the common centre of gravity C, are reciprocally as the weights of the bodies A and B; that is, A C : B C :: B : A.

PROP. I. *If a body by an uniform motion, describe one side of a parallelogram, in the same time that it would describe the adjacent side by an accelerative force; this body, by the joint action of these forces, would describe a curve, terminating in the opposite angle of the parallelogram.*



297. Let ABDC be a parallelogram, and suppose the body A to be carried through AB by an uniform force in the same time that it would be carried through AC by an accelerative force, then by the joint action of these forces, the body would describe a curve AGID. For, by the preceding illustration, (Art. 293.) if the spaces AE, EK, and KB, be proportional to each other, the spaces AF, FH, and HC, will be in the same proportion, and the line AGID will be a straight line when the body is acted upon by uniform forces; but in this example, the force in the direction AB being uniform, would cause the body to move over equal spaces AE, EK, and KB, in equal portions of time: while the accelerative force in the direction AC, would cause the body to describe spaces AF, FH, and HC, increasing in magnitude in equal successive portions of time, hence the parallelograms AEGF, AKIH, &c. are not about the same diagonal, therefore AGID is not a straight line, but a curve.

Prop. II. *The curvilinear motions of the planets arise from the uniform projectile motion of bodies in straight lines, and the universal power of attraction which draws them off from these lines.*



298. If the body E be projected along the straight line EAF, in free space where it meets with no resistance, and is not drawn aside by any other force, it will (by the first law of motion) go on for ever in the same direction, and with the same velocity. For, the force which moves it from E to A in a given time, will carry it from A to F in a successive and equal portion of time, and so on; there being nothing either to obstruct or alter its motion. But, if, when the projectile force has carried the body to A, another body as S, begins to attract it, with a power duly adjusted and perpendicular to its motion at A, it will be drawn from the straight line EAF, and revolve about S in the circle* AGOOA. When the body E arrives at O, or any other part of its orbit, if the small body M, within the sphere of E's attraction, be projected, as in the straight line M *n*, with a force perpendicular to the attraction of E, it will go round the body E, in the orbit *m*, and accompany E in its whole course round the body S.—Here S may represent the sun, E the earth, and M the moon.

If the earth at A be attracted towards the sun at S, so as to fall from A to H by the force of gravity alone in the same time which the projectile force singly would have carried it from A to F; by the combined action of those forces it will describe the curve AG; and if the velocity with which E is projected from A, be such as it would have acquired by falling from A to V (the half of AS,) by the force of gravity alone†, it will revolve round S in a circle.—*Keith.*

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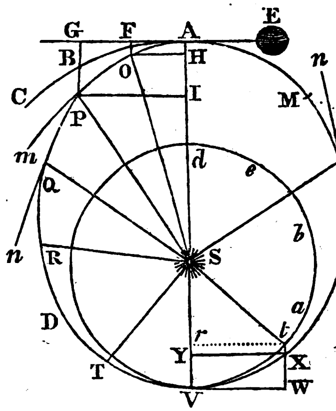
* If any body revolve round another in a circle, the revolving body must be projected with a velocity equal to that which it would have acquired by falling through half the radius of the circle, towards the attracting body. *Emerson's Cent. Forces*, Prop. ii.

† A body, by the force of gravity alone, falls 16$\frac{1}{12}$ feet in

Prop. III. *If one body revolve round another (as the earth round the sun), so as to vary its distance from the centre of motion, the projectile and centripetal forces must each be variable, and the path of the revolving body will differ from a circle.*

299. Thus, if while a projectile force would carry a planet from A to F, the sun's attraction at S would bring it from A to H, the gravitating power would be too great for the projectile force; the planet, therefore, instead of proceeding in the circle ABC (as in the preceding article) would describe the curve AO, and approach nearer to the sun; SO being less than SA. Now, as the centripetal force, or gravitating power, always increases as the square of the planet's distance from the sun diminishes *, when the planet arrives at O the centripetal force will be increased, which will likewise increase the velocity of the planet, and accelerate its motion from O to V; so as to cause it to describe the arcs OP, PQ, QR, RD, DT, TV, successively increasing in magnitude, in equal portions of time. The motion of the planet being thus accelerated, it gains such a centrifugal force, or tendency to fly off at V, in the line VW, as overcomes the sun's attraction; this centrifugal or projectile force being too great to allow the planet to approach nearer the sun than it is at V, or even to move round the sun in circle *t a b c d*, &c. it flies off in the curve XZMA, with a velocity decreasing as gradually from V to A, as if it had returned through the arcs VT, TD, DR, &c. to A, with



the first second of time, and acquires a velocity which will carry it uniformly through 32⅙ feet in each succeeding second. This is proved experimentally, by writers on mechanics.

* Newton's Princip. Book III. Prop. ii.

the same velocity which it passed through these arcs in its motion from A, towards V. At A the planet will have acquired the same velocity it had at first, and thus by the centrifugal and centripetal forces it will continue to move round S.

Two very natural questions may here be asked; *viz.* why the action of gravity, if it be too great for the projectile force at O, does not draw the planet to the sun at S? and why the projectile force at V, if it be too great for the centripetal force, or gravity, at the same point, does not carry the planet farther and farther from the sun, till it is beyond the power of his attraction?

First. If the projectile force at A were such as to carry the planet from A to G, double the distance, in the same time that it was carried from A to F, it would require four * times as much gravity to retain it in its orbit, *viz.* it must fall through AI in the time that the projectile force would carry it from A to G, otherwise it would not describe the curve AOP. But an increase of gravity gives the planet an increase of velocity, and an increase of velocity, increases the projectile force; therefore, the tendency of the planet to fly off from the curve in a tangent P *m*, is greater at P than at O, and greater at Q than at P, and so on; hence, while the gravitating power increases, the projectile power increases, so that the planet cannot be drawn to the sun.

Secondly. The projectile force is the greatest at, or near, the point V, and the gravitating power is likewise the greatest at that point. For if AS be double of VS, the centripetal force at V will be four times as great as at A, being as the square of the distance from the sun. If the projectile force at V be double of what it was at A, the space VW, which is the double of AF, will be described in the same time that AF was described, and the planet will be at X in that time. Now, if the action of gravity had been an exact counterbalance for the projectile force during the time mentioned, the planet would have been at *t* instead of X, and it would describe the circle, *t*, *a*, *b*, *c*, &c.; but the projectile force being too powerful for the centripetal force, the planet recedes from the sun at S, and ascends in the curve XZM, &c. Yet, it cannot fly off in a tangent in its ascent, because its velocity is retarded, and consequently its projectile force is diminished, by the action of gravity. Thus, when the planet arrives at Z, its tendency to fly off in a tangent Z *n*, is just as much retarded, by the action of gravity as its motion was accelerated thereby at Q, therefore it must be retained in its orbit.—*Keith on the Globes.*

* Ferguson's Astronomy, Art. 153.

CHAPTER XII.

CHRONOLOGICAL SCIENCE.

SECTION I.

OF TIME AND ITS PARTS.

200. CHRONOLOGY is that science which treats of time, and shews its different measures or computations, as they have been observed by different nations.

By chronology we are enabled truly to date the beginning and end of the reigns of princes, the births and deaths of eminent persons, the revolutions of empires, and kingdoms, battles, sieges, or any other remarkable events. Without this useful science, that is to say, without distinguishing the times of events as clearly as the nature of the case will admit, history would be little better than a *heap* of confusion, destitute of light, order, or beauty.

201. *Time.* Its usual divisions are years, months, weeks, days, hours, minutes, and seconds; besides periods, centuries, and cycles.

A year is the most complete period of time, being that in which all the seasons return in succession, and begin anew.

It is that space of time wherein the earth finishes its course round the sun, returning to the same point from which it departed.

This consists of three hundred and sixty-five days, five hours, and forty-nine minutes; and is called the *tropical, natural,* or *solar.*

But that period of time in which the sun having departed from any fixed star, returns to the same again, is called the *sidereal* year, and contains three hundred and sixty-five days, six hours, ten minutes.

A *lunar* year is that space of time, in which the moon performs twelve complete revolutions round the earth, called *Lunations*. This year contains three hundred and fifty-four days, eight hours, forty-eight minutes, and thirty-eight seconds.

Both the *tropical* and *lunar* years above described, are termed astronomical, as depending on the principles and observations of astronomy.

A *civil* year is the legal year, or that which each nation or government has appointed for common use. This is made to consist of a certain number of whole days, without any odd hours or minutes, to render the computation of time more easy. It is distinguished into *common* and *bissextile*. The common year consists of three hundred and sixty-five days; and the *bissextile*, or leap year, which is every fourth, of three hundred and sixty-six.

The addition of a day to every fourth year is to make the *civil* year keep pace with the *natural* one: for the six hours, or thereabouts, by which the latter exceeds the former, in four years make a whole day; and therefore every leap-year the month of February has twenty-nine days, which in the common year has but twenty-eight.

The reformation of the calendar is called the Gregorian account, or New Stile; and according to this stile was the calendar rectified in England in 1752, by throwing out eleven days in the month of September, as from the council of Nice to that year, 1427 years had elapsed; and, besides the beginning of the civil year was fixed to the first day of January,

SECTION II.

OF THE FORMS OF CIVIL YEARS.

302. There have been, and there still are, various forms of *civil* years, in different nations, four of which we shall here enumerate.

I. The *ancient Roman year* of Romulus consisted of ten months, namely, *Martius* of thirty-one days, *Aprilis* of thirty, *Maius* of thirty-one, *Junius* thirty, *Quintilis* of thirty-one, *Sextilis* of thirty, *September* of thirty, *October* of thirty-one, *November* of thirty, *December* of thirty; in all three hundred and four days.

II. The Roman year of *Numa* consisted of twelve months. *Januarius* had twenty-nine days, *Februarius* twenty-eight, *Martius* thirty-one, *Aprilis* twenty-nine, *Maius* thirty-one, *Junius* twenty-nine, *Quintilis* thirty-one, *Sextilis* twenty-nine, *September* thirty-one, *October* twenty-nine, *November* twenty-nine, *December* twenty-nine; in all three hundred and fifty-five.

The months called Quintilis and Sextilis, from their order in Romulus's year, were changed into Julius and Augustus, in honour of Julius Cæsar and his successor Augustus.

III. The *Julian* year consists of twelve months, viz. *January* of thirty-one days, *February* of twenty-eight, *March* of thirty-one, *April* of thirty, *May* of thirty-one, *June* of thirty, *July* of thirty-one, *August* of thirty-one, *September* of thirty, *October* of thirty-one, *November* of thirty, *December* of thirty-one; in all three hundred and sixty-five.

Every fourth year, in the Julian account, has three-hundred and sixty-six days, February then having twenty-nine, as we have before observed.

The *Gregorian* year has the same number of months and days as the Julian, the only difference being that each month in the former begins *eleven* days sooner than in the latter.

IV. The *Jewish* year consists of twelve months, *Nisan* or *Abib* has thirty days, *Jiar* or *Zius* twenty-nine, *Siban* or *Sivan* thirty, *Thamus* or *Tamus* twenty-nine, *Ab* thirty, *Elul* twenty-nine, *Tisri* or *Ethanim* thirty, *Marchesvan* or *Bul* twenty-nine, *Cisleu* thirty, *Tebeth* twenty-nine, *Shebat* or *Schebeth* twenty-nine, *Adar* twenty-nine; in all three hundred and fifty-four.

This is made to agree with the *solar year*, by adding eleven, and sometimes twelve days.

As the form of the year is various among different nations, so likewise is its beginning. The Jews, like other nations of the East, had a civil year, which commenced with the moon in September; and an ecclesiastical year, which began from the new moon in March. The Persians begin their year in the month answering to June. The Chinese, and most of the Indian nations, begin it with the first moon in March; and the Greeks with the new moon that happens next after the summer solstice.

In England, the civil or legal year formerly commenced on the 25th of March, and the historical year on the first day of January. But since the alteration of the style, in 1752, the civil year, in this country, as we observed before, has likewise begun on the first of January.

In the year of Christ 200, there was no difference of styles, but there is now a difference of eleven days between the old style and the new, the latter much before hand with the former.

At the diet of Ratisbon in 1700, it was decreed by the body of Protestants of the empire, that eleven days should be retrenched from the old style, in order to accommodate it to the new, and the same regulation has since passed into Sweden, Denmark, and England; where it was established by 24 Geo. II. c. 23. which enacts, that the supputation, according to which the year of our Lord begins on the twenty-fifth day of March, shall not be used from and after the last day of December, 1751. And that from thenceforth the first day of January every year shall be reckoned the first day of the year and that the natural day next immediately following the second day of September, 1752, shall be called and reckoned the 14th day of September, omitting the eleven intermediate days of the common calendar, and the several natural days succeeding the fourteenth day, shall be called and reckoned in numerical order. The adoption of the Gregorian computation accordingly took place in 1752, and is now recognized throughout the kingdom.

SECTION III.

OF MONTHS, WEEKS, DAYS, HOURS, AND MINUTES.

303. THE principal division of the year is into parts called months, which are usually twelve; and these are either *astronomical* or *civil*.

Illus. An *astronomical* or *natural* month is measured exactly by the motion of the earth or moon, and is accordingly either *lunar* or *solar*.

A *lunar* month is the time the moon takes to revolve round the earth. And this revolution is completed in twenty-seven days, seven hours, forty-three minutes, and eight seconds.

A *solar* month is that space of time in which the earth measures one of the signs of the *Zodiac*. And as the earth constantly travels through all the twelve signs in three hundred and sixty-five days, five hours, and forty-nine minutes, the quantity of a mean solar month is found by dividing that number by twelve. And hence it appears that each of these months, one with another, contains thirty days, ten hours, twenty-nine minutes, and five seconds.

Civil months are those which are framed to serve the uses of life, being made to consist of a certain number of whole days.

304. *January* is the first month in the year among the western nations. The word is derived from *Januarius*, a name given it by the Romans from *Janus*, one of their divinities, to whom they attributed two *faces*: because on the one side the first of January looked towards the new year, and on the other towards the old one. The word Januarius may also be derived from *janua*, a gate; for the first month is as the gate of the year. Numa Pompilius made January the first month, Romulus' year beginning in the month of March.

February is derived from *Februa*, an old Latin word, for, from the very foundation of the city, we meet with *Februa* for purification; and *Februare*, to purge or purify. In this month the Romans held a feast in behalf of the *manes* of the deceased; and *Macrobius* tells us, that in this month, also, sacrifices were performed, and the last offices were paid to the defunct.

March, (the *third* month according to *our* computation,) was considered as the first by some of the antients, and by others as the third, fourth, or fifth, and even the tenth month of the year. *Romulus* named it after his supposed father *Mars*, and appointed it as the first month of the year.

April, (in Latin *Aprilis*) is derived from *aperio*, I open; because the earth in this month, begins to open her bosom for the production of vegetables.

May, the fifth month, was called *Maius* by *Romulus*, from respect to the senators and nobles of the city, who were named *Majores:* though others say, that it was so called from *Maia*, the mother of Mercury, to whom they offered sacrifice in that month.

June, by the Romans called *Junius*, in honour of the Roman youth, who served *Romulus* in war; some derive the word *Junius à Junone*, from *Juno*.

July, is the seventh month, the word is derived from the Latin *Julius*, the surname of *C. Cæsar* the dictator, who was born in this month. *Marc Antony* first gave this month the name of *July*, which was before called *Quintilis*, as being the fifth month of the year in the old Roman calendar. For the same reason August was called *Sextilis*, and September, October, November, and December, still retain their original names.

August, in a general sense, implies something majestic, and the appellation was first conferred on *Octavius*, by the Roman senate, then named *Augustus Cæsar*, who was in this month created consul; he had thrice triumphed in Rome, subdued Egypt to the Roman empire, and terminated the civil wars: on this account the month was dedicated to his honour, and still called after his name.

September, from *Septimus* the seventh month, reckoning from *March*, which was the first month of the antients. The Roman senate would have given this month the name of *Tiberius;* but the emperor opposed it. Under other emperors it had other names; but at pesent they are all disused.

October, the eighth month in the year of Romulus's calendar, though the tenth in that of *Numa*, *Julius Cæsar*, &c. still retains its name.

November, the ninth month in the year of Romulus, (whence its name) is the eleventh of the Julian year.

December, (from *Decem*,) was the tenth month of the year of Romulus. And it is the last now with us, being the period of the winter solstice.

A month is divided into four parts called weeks, each consisting of seven parts called days. Of these months there are thirteen in a Julian year, and one day over; of weeks there are fifty-two, and of days three hundred and sixty-five, as before observed.

The days of the week are SUNDAY, from the *Sun*; MONDAY, from the *Moon*; TUESDAY, from *Tuisco*, a Saxon hero; WEDNESDAY, from *Woden*, the god of battle; THURSDAY, from *Thor*, the god of winds; FRIDAY, from *Friga*, the goddess of peace; and SATURDAY, from *Sator*, the god of freedom.

The *Romans* divided their months into *calends*, *nones*, and *ides*; calling the first day of every month its *calends*.

The *Romans* called the days of the week after the planets:—as *dies Solis*, day of the sun; *dies Lunæ*, day of the moon; *dies Martis*, day of Mars; *dies Mercurii*, day of Mercury; *dies Jovis*, day of Jove; *dies Veneris*, day of Venus; *dies Saturni*, day of Saturn.

A True Solar Day is the time from the sun's leaving the meridian of any place, on any day, till it returns to the same meridian on the next day; viz. it is the time elapsed from twelve o'clock at noon, on any day, till twelve o'clock at noon on the next day, as shewn by a correct sun-dial.

A true solar day is subject to continual variation, arising from the obliquity of the ecliptic, and the unequal motion of the earth in its orbit; the duration thereof sometimes exceeds, at others, falls short, of twenty-four hours, and the variation is the greatest about the first of November, when the true solar day is 16′ 15″ less than twenty-four hours, as shewn by a well regulated clock.

A mean Solar Day is measured by equal motion, as by a clock or time-piece, and consists of twenty-four hours. There are in the course of a year as many mean solar days as there are true solar days, the clock being as much faster than the sun-dial on some days of the year, as the sun-dial is faster than the clock on others.

Thus the clock is faster than the sun-dial from the twenty-fourth of December to the fifteenth of April, and from the sixteenth of June to the thirty-first of August: but from the fifteenth of April, to the sixteenth of June, and from the thirty-first of August to the twenty-fourth of December, the sun-dial is faster than the clock. When the clock is faster than the sun-dial, the true solar day exceeds twenty-four hours; and when the sun-dial is faster than the clock, the true solar day is less than twenty-four hours; but when the clock and the sun-dial agree, viz. about the fifteenth of April, sixteenth of June, thirty-first of August, and twenty-fourth of December, the true solar day is exactly twenty-four hours.

The *Astronomical Day*, is reckoned from noon to noon, and consists of twenty-four hours. This is called a *natural* day, being of the same length in all latitudes.

The *Artificial Day* is the time elapsed between the sun's rising and setting, and is variable according to the different latitudes of places.

The *Civil Day*, like the astronomical or natural consists of twenty-four hours, but begins differently in different nations.

The ancient Babylonians, Persians, Syrians, and most of the eastern nations, began their day at sun-rising. The ancient Athenians, the Jews, &c. began their day at sun-setting, which custom is followed by modern Austrians, Bohemians, Silecians, Italians, Chinese, &c. The Arabians begin their day at noon, like the modern astronomers. The ancient Egyptians, Romans, &c. began their day at midnight, and this method is followed by the English, French, Germans, Dutch, Spanish, and Portuguese.

A *Sidereal Day* is the interval of time from the passage of any fixed star over the meridian, till it returns to it again: or, it is the time which the earth takes to revolve once round its axis, and consists of twenty-three hours, fifty-six minutes, four seconds, of mean solar time.

In elementary books of astronomy and the globes, the learner is generally told that the earth turns on its axis from west to east in twenty-four hours; but the truth is, that it turns on its axis in twenty-three hours, fifty-six minutes, four seconds, making about three hundred and sixty-six revolutions in three hundred and sixty-five days, or a year. The natural day would always consist of twenty-three hours, fifty-six minutes, four seconds, instead of twenty-four hours, if the earth had no other motion than that on its axis; but while the earth has revolved eastward once round its axis, it has advanced nearly one degree * eastward on its orbit. To illustrate this, suppose the sun to be upon any particular meridian at twelve o'clock, on any day; in twenty-three hours, fifty-six minutes, four seconds afterwards the earth will have performed one entire revolution; but it will at the same time have advanced nearly one degree eastward, in its orbit, and consequently that meridian which was opposite to the sun the day before, will now be one degree westward of it; therefore the earth must perform something more than one revolution before the sun appears again on the same meridian; so that the time from the sun's being on the meridian on any day, to its appearance on the same meridian the next day, is twenty-four hours.

IDES, (*idus*) in the Roman calendar, a denomination given to eight days in each month; commencing in the months of March, May, July, and October, on the fifteenth day, and in the other months, on the thirteenth day; and reckoned backward, so as

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* The earth goes round the sun in 365¼ days nearly; and the ecliptic, which is the earth's path round the sun, consists of 360 degrees; hence by the rule of three, 365¼ D : deg. : : 1 D : 59′ 8″. 2, the daily mean motion of the earth in its orbit, or the *apparent* mean motion of the sun in a day. Hence a clock, or chronometer, the index of which performs an exact circuit whilst the earth (or the meridian of an observer) moves over 360° 59′ 8″. 2 is said to be adjusted to mean solar time.

in the four months above specified to terminate on the eighth day, and in the rest on the sixth. The Ides came between the calends and the nones.

The fifteenth day, in March, May, July, and October, and the thirteenth in the other months, was called the Ides of these months; *Idus Marti*, *Idus Maii*, &c. The thirteenth day in the four months, and the eleventh in the eighth, was called the third of the Ides of such months, third *Idus Martii*, &c. So the twelfth day in the four, and the tenth day in the eight months, were the fourth of the Ides, fourth *Idus Martii*, &c. And thus of the rest, to the eighth and sixth days, which made the eighth of the Ides, eight *Idus Martii*, &c.

This way of accounting is still in use, in the Roman chancery, and in the calendar of the breviary. The Ides of May were consecrated to Mercury; the Ides of March were ever esteemed unhappy, after Cæsar's murder on that day; the time after the Ides of June was reckoned fortunate for those who entered into matrimony: the Ides of August were consecrated to Diana, and were observed as a feast day by the slaves. On the Ides of September auguries were taken for appointing the magistrates, who formerly entered into their offices on the Ides of May, afterwards on those of March.

CALENDS, (*Calendæ*) in the Roman chronology, the first day of every month.

The word is formed from the Latin *calo*, or rather, Greek, I call, or proclaim; because, before the publication of the Roman fast, it was one of the offices of the Pontifices to watch the appearance of the new moon, and give notice to the *Rex Sacrificulus*; upon which a sacrifice being offered, the pontiff summoned the people together in the capital, and there with a loud voice proclaimed the number of calends, or the day whereon the nones would be; which he did by repeating this formula, as often as they were days of calends, *Calo, Juno, Novella*. Whence the name *Calendæ* was given thereto, from *calo calare*. This is the account given by *Varro*.

NONES, (*Nonæ*) in the Roman calendar, the fifth day of the months January, February, April, June, August, September, November, and December, and the seventh of March, May, July, and October. These four last months having six days before the Nones, and the other only four.

The word apparently has its rise hence, that the day of the Nones was nine days before the Ides, and might be called *Nono Idus*.

March, May, July, and October, had six days in their Nones; because these alone, in the antient constitution of the year by Numa, had thirty-one days each, the rest having only twenty-nine, and February thirty. But when Cæsar reformed the year, and made other months contain thirty-one days, he did not likewise allow them six days of Nones.

An *hour* is the twenty-fourth part of a natural day.

Different people reckon the hours in a different manner. Babylonish hours are those which are counted from sun-rising in a continued series of twenty-four. European hours are those counted from midnight, twelve from thence to noon, and from noon to midnight twelve more. Those which commence their order from noon are called *astronomical*, because used by astronomers.

The Jews, Chaldeans, Arabs, and other eastern people, divide their hours into a *thousand* and *eighty* scruples, eighteen whereof are equal to our minute.

SECTION IV.

OF CYCLES, EPACTS, &c.

305. A CYCLE is a circle of years, months, and days, used by chronologers, to signify a perpetual round or circulation of the same parts of time, proceeding orderly from first to last, and recurring again from last to first, successively, and without interruption.

As the annual motion of the sun, and other heavenly bodies, cannot be measured exactly without any remainder of minutes, seconds, &c. to swallow up these fractions in whole numbers, that is such as only express days and years, *cycles* have been invented; which, comprehending several revolutions of the same body, replace it, after a certain number of years, in the same point of the heavens whence it first departed; or which is the same thing, in the same place of the civil calendar.

The most famous cycles are, the *Cycle of the Moon*, the *Cycle of the Sun*, and the *Cycle of Indiction.*

The cycle of the moon, or *lunar cycle*, called also the *Metonic* cycle, from its inventor *Meton*, an Athenian, is a circle or revolution of nineteen years, in which time the new and full moons are supposed to return to the same day of the month in the Julian calendar.

The cycle of the sun, or *solar cycle*, is a revolution of twenty-eight years. When these are elapsed, the *Dominical*, or Sunday Letters, in the calendar, return into their former place, and proceed in the same order as before. It is from these *Sunday Letters*, and not for any regard for the sun's course, that the cycle has obtained its name.

The *cycle of Indiction* is a circle or revolution of fifteen years, which when expired begins anew, and goes round again without intermission.

This cycle has no relation to the celestial motions, but was made use of by the Romans to make known the time of paying certain taxes, or for other civil purposes.

The popes have dated their bulls by the *year* of the *indiction* ever since the time of Charlemagne.

The *prime* or *golden number* is a revolution of nineteen years, and is that particular number which shews the year of the lunar cyle, for any given year. Hence to find the year of the lunar cyle is to find the golden number.

The numbers are called *golden*, because, being of excellent use, they were expressed in ancient calendars by figures of gold.

Illus. 1. The solar cycle consists of twenty-eight years, when the sun returns to the sign of the ecliptic which he had occupied at the conclusion of the preceding period, and the days of the week correspond to the same days of the month as at that time.

2. The first year of the Christian era corresponds to the ninth of the solar cycle: if therefore 9 be added to the year 1814, and the sum be divided by 28, the quotient denotes the

number of the revolutions of the cycle since the ninth year before Christ, and the remainder will be the year of the cycle.

Example for the year 1814:

$$\frac{1814 + 9}{28} = \frac{1823}{28} = 65\tfrac{3}{28}$$

Therefore there have been 65 complete solar cycles, and the year of the cycle for 1814 is 3.

3. The cycle of Roman indiction consist of fifteen years, and the first year of it corresponds to the third year before the Christian era.

4. To find the year of the Roman indiction, add 3 to the year 1814, and divide by 15; the quotient gives the number of cycles since the third year before Christ, and the remainder is the year of the cycle.

Example for the year 1814:

$$\frac{1814 + 3}{15} = \frac{1817}{15} = 121\tfrac{2}{15}$$

Therefore there have been 121 complete cycles, and the year 1814 is the second year of the cycle. Had there been no remainder in this and the foregoing examples, then the golden number would have been 19: the solar cycle 28; and the Roman indiction 15.

5. The *dominical*, or Sunday letter in the Almanack, is thus found, the days of the weeks are named A, B, C, D, E, F, G, and A is always put for the first day of the year, B for the second, &c. In the year 1814 the first day being Saturday, or A; the second, or Sunday, will be marked B: of course the Dominical letter is B.

6. The golden number, or year of the lunar cycle, is found by adding 1 to the present year, and dividing by 19, the quotient shows the number of cycles which have revolved since the Christian era, and the remainder is the golden number for the given year.

Example for the year 1814: to the year I add 1 and divide by 19,

$$\frac{1815}{19} = 95\tfrac{10}{19}$$

Therefore there have been ninety-five complete cycles since the birth of Christ, and the golden number for the year 1814 is ten.

Epacts are, as the word implies, *added numbers*; that is, a number of days added to the lunar year, to make it equal to the solar year.

The solar year has 365 days, and almost six hours; and the lunar year 354 days, and upwards of eight hours. The difference is the *epact*. Now as this difference is not much short of eleven days, it was made the epact of the first year of the lunar cycle.

SECTION V.

PERIODS OF TIME, ÆRAS, CENTURIES, &c.

306. A PERIOD is a series, or circle, of a certain number of years, used for measuring or computing time. Of these there are several, most of which take their names from the persons who invented them.

Of the *Metonic* period, or *lunar cycle* of 19 years, it is needless to say any thing more. It has been sufficiently explained.

The *Calippic* period, so called from its inventor Calippus, is a series of 76 years, which being elapsed, Calippus supposed that the new and full moons would return to the same day of the solar year. This was intended as an improvement of the *Metonic* period.

The *Victorian* period is a series of 532 years, arising from the cycles of the sun and moon multiplied into one another.

It was invented by *Victorius*, a French Clergyman, about the middle of the fifth century, and used by the western churches for many ages, in computing the time of Easter, till the *Gregorian* reformation of the calendar.

The famous *Julian* period is a series of 7980 years, arising from the multiplication of the cycles of the sun, moon, and indiction into one another.

This period is said to have been invented by Joseph Scaliger; and is called Julian as being adapted to the Julian year. As it commences before the Creation, and still wants about 1500 years of being completed, it therefore comprehends all other cycles, periods, and epochas, and, in short, the times of all actions and events, from the beginning of the world.

An *Epocha*, or *Æra*, is a certain fixed point of time, made famous by some remarkable event; from whence, as from a root, the ensuing years are numbered or computed.

As there is no astronomical consideration to render one epocha preferable to another, their constitution is purely arbitrary, and therefore various epochas have been used at different times, and among different nations.

The *Christian Epocha* commences on the 25th of December, or the 1st of January. But in those countries which observe the Julian calendar, it commences on the 25th of March.

The author of this way of computing from Christ, was Dionysius Exiguns, a Roman abbot, who lived about the begining of the sixth century.

The *Epocha of the Creation*, according to the Jewish computation, is the year of the *Julian* period 953, answering to the year of Christ 3761; and commencing on the 7th of October. Hence, if we subtract 952 from any given year of the Julian period, the remainder is the corresponding year of the Jewish epocha of the creation.

The *Epocha of the Olympiads*, used principally by the Greeks, is famous in ancient history.

It took its rise from the Olympic games, which were celebrated at the beginning of every fifth year, near Olympia, a city of Elis, in Peloponnesus. An Olympiad, therefore, was a period of four years; and by these periods the Greeks reckoned their time, the year in which the games were celebrated being the first year of the Olympiad.

The beginning of the first Olympiad is referred to the year of the Julian period 3931, or 776 years before Christ.

The *Epocha of the Building of Rome*, was the principal one among the Romans. This Epocha is the year of the *Julian* period 3961, and answers to the year 752 before Christ, commencing on the 21st of April.

The *Dioclesian Epocha*, or epocha of the *Martyrs*, commences in the year of Christ 284, and that of the Julian period 4997. It obtained its name from the great number of Christians who suffered martyrdom in the reign of the emperor Dioclesian.

The *Epocha of the Hegira* is used by the Turks, Arabs, and others who profess the Mahometan faith. It commences on the 16th of July, in the year of Christ 622, and of the Julian period 5335.

The word *hegira*, signifies *flight*; the event which gave occasion to this epocha being Mahomet's flight from Mecca. The magistrates of that city, finding that his imposture tended to disturb the public peace, were determined to cut off the author of it, to prevent the further spreading of the mischief. But Mahomet, having timely notice of their design, fled by night to Medina, another city of Arabia, in the year of our Lord above mentioned: and this is the principal æra from which the Mahometans compute their time.

A *Century*, or an *age*, is a course of an hundred years.

A *Lustrum* is a space of five years, used by the Romans, at the end of which a review of the people was made, first by the kings, then by the consuls, but after the year 310 by the censors, who were magistrates created for that very purpose.

After the *census* was finished, an expiatory or purifying sacrifice was made, consisting of a sow, a sheep, and a bull, which was carried round the whole assembly, and then slain: and thus the people were said to be purified*. And because this was done at the end of every fifth year, hence *lustrum* is often put for the space of five years, especially by the poets,

At every *lustrum* the senate itself was reviewed by one of the censors; and if any one, by his behaviour, had rendered himself unworthy of that high rank, or had sunk his fortune below that of a senator, his name was passed over by the censor in reading the roll of senators; and thus he was held to be excluded from the senate†.

A *jubilee* is a periodical festivity, or public rejoicing, on account of some remarkable event, or in memory of some eminent person.

According to the æra by which we reckon, we date the

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* Lustrari. † E Senatu motus.

time of every memorable transaction, as, A. M. *Anno Mundi*, in the year of the world. A. D. *Anno Domini*, in the year of our Lord. A. C. *Ante Christum*, before Christ; and sometimes B. C. is put for before Christ. A. Æ. C. *Anno Æræ Christianæ*, in the year of the Christian æra. A. U. C. *Anno Urbis Conditæ*, in the Year of the building of the city of Rome; or A. ab. U. C. in the Year of the building of the city; and so of the other epochas.

CHAPTER XIII.

HERALDRY.

INTRODUCTION.

307. The science of heraldry consists in blazoning and marshalling arms. The word *blazoning* is borrowed from the French *emblazoner*; and signifies displaying or explaining the several emblems and colours of an achievement in proper terms.

The blazoning of the arms of gentlemen, esquires, knights, and baronets, is derived from metals and colours; those of barons, viscounts, earls, marquisses, and dukes, from precious stones; and those of princes, kings, and emperors, from the planets.

Marshalling is the orderly disposition of several coats of arms, belonging originally to different families, within one shield or escocheon, together with all the proper armorial ensigns, ornaments, and decorations. We will in this chapter *first* notice the four great orders of British knighthood; *secondly*, we will explain the various heraldic terms.

SECTION I.

BRITISH ORDERS OF KNIGHTHOOD, ARE,

1. *Order of the Garter.*

308. This order is military, and was instituted by Edward III. in 1344, under the title of the Sove-

reign, and Knights-companions of the most noble order of the Garter. Some alterations were made in 1557, and 1788.

It consists of twenty-six knights or companions, generally peers or princes; of whom the king of England is sovereign or chief. They are a corporation, having a great and little seal; and their chief officers are, a prelate, chancellor, register, king-at-arms, and usher. They have also a dean, twelve canons, petty canons, vergers, and twenty-six pensioners, or poor knights. The order is under the patronage of *St. George* of Cappadocia, the tutelar saint of this kingdom. Their college is held in Windsor Castle, within the chapel of *St. George*, and the chapter-house, erected by the founder for that purpose.

Various are the accounts of the origin of this order. The popular tradition is, that it was erected in honour of a garter which fell from the knee of the Countess of Salisbury, and which Edward picked up and presented to her with these words, *Honi soit qui mal y pense*. This idea is derided by the antiquarians, Camden and Fern, who choose rather to find its birth-place the victory of Cressy.

The habit and ensigns of the order consists of a *surcoat*, *garter*, *mantle*, *hood*, *george*, *cap*, and *feathers*.

2. *The Order of the Thistle.*

309. This order, instituted by Achaius, king of Scotland, in 787, was restored by James V. 1540, revived by king James II. in 1687, and re-established by queen Anne, in 1703. It is therefore far more ancient than the order of the Garter.

It consists of the sovereign and twelve brethren or knights, making in the whole thirteen, and four officers. The star is worn on the left side of the coat or cloak, and consists of a St. Andrew's cross, of silver embroidery, with rays going out between the points of the cross; on the middle a thistle of gold and green upon a field of green, and round the thistle and field a circle of gold, having on it the following motto, in green letters: NEMO ME IMPUNE LACESSIT, (no man provokes me with impunity.) The badge or jewel worn pendant to a green riband over the left shoulder, and tied under the arm, consists of the image of St. Andrew, with the cross before, enamelled and chased on rays of gold, the cross and feet resting upon a ground of enamelled green; and on the back enamelled on a green ground, a thistle gold and green, the flower reddish, with the above motto round it. The collar is composed of thistles, and sprigs of rue interspersed, and from the centre is suspended the image of St. Andrew, the whole being of gold enamelled.

3. *The Order of the Bath.*

310. Instituted in England at the coronation of Henry IV. 1339, and revived by George I. was made a statutable order in 1725. The number of the knights is at the sovereign pleasure.

The badge or ensign of this order is a *rose*, *thistle*, and *shamrock*, issuing from a sceptre between three imperial crowns, surrounded with this motto, TRIA JUNCTA IN UNO, signifying the three theological virtues, *faith*, *hope*, and *charity*. The whole is of pure gold, chased and pierced, and is worn by the knight elect, pendant from a red riband across the right shoulder. The collar is of gold, composed of nine imperial crowns, eight roses, thistles, and shamrocks issuing from a sceptre, enamelled in their proper colours, and linked together with seventeen gold knots, enamelled white. The star consists of three imperial crowns of gold, surrounded by the motto upon a circle of red, with silver rays issuing from the centre, forming a star, and is embroidered on the left side of the upper garment. No knight elect can wear either the collar or star before his installation, without leave from the sovereign.

4. *The Order of St. Patrick.*

311. This order was instituted by George III. in 1783. It consists of the sovereign, a grand master, a prince of the blood royal, and thirteen knights, making in the whole sixteen, and seven officers. The lord lieutenant for the time being is the grand master.

The star is charged with three imperial crowns of gold, within a circle of gold, with the motto, QUIS SEPARABIT, MDCCLXXXIII. the whole surrounded with eight rays of silver, and is embroidered on the left side of the coat or cloak. The collar is of pure gold, composed of six harps and five roses, alternately joined together by five knots. In the centre before is a crown, from which is suspended the badge or jewel of the order, of gold enamelled, which (the rays excepted) is similar to the star.

SECTION II.

TITLES OF HONOUR, AND HERALDIC TERMS ALPHABETICALLY ARRANGED.

312. Titles were not common among the ancient Greeks and Romans. In the reign of Constantine the title of *illustrious* was never given except to those distinguished in arms or letters: but in process of time it became hereditary in the families of princes, and every son of a prince was illustrious.

The title of *highness* was formerly given only to kings. The kings of England, before the reign of Henry VIII. were addressed by the title of *your grace.* Since that period they had the title of *king of Great Britain, France, and Ireland;* but since the union with Ireland, the title is simply, *king of the British Isles:* the king of France had the title of *king of France and Navarre;* the king of Spain had a whole page of titles to express the several kingdoms and territories he is master of; the king of Sweden entitled himself *king of the Swedes and Goths;* the king of Denmark, *king of Denmark;* the king of Sardinia among his titles took that of *king of Cyprus and Jerusalem.*

The duke of Lorraine the title of *king of Jerusalem and Sicily.*

The pope that of *Holiness;* a cardinal prince of the blood, *royal highness,* or *most serene highness;* other cardinal princes, *most eminent highness;* archbishop, *grace* and *most reverend;* a bishop, *right reverend:* abbots and priests, *reverend.*

An Emperor has the title of *imperial majesty;* kings that of *majesty;* the king of France is his *Christian,* the king of Spain his *catholic majesty;* and the king of England is *defender of the faith.*

The emperor of Turkey is *grand Seignior,* the prince of Wales, *royal highness;* an ambassador is *his excellency.* But a Chinese sovereign is *son of heaven.*

An *Abatement* is a casual mark annexed to a coat of armour, to announce some dishonourable act of the bearer.

An *Achievement* is composed of the shield or escocheon, the mantle, helmet, and crest.

A *Hatchment* is the arms of a person deceased, painted and affixed to his residence.

Hatchments are differently formed, according to the condition of the deceased.

Thus, a *Bachelor* has his arms single or quartered, but never impaled; the hatchment bears a crest, and the ground without the escocheon black.

A *Single Woman* has her arms placed in a lozenge, single or quartered, with the ground black, and a shell instead of a crest. Ensigned on the hearse with a knot of ribands.

Married Man has wife's arms impaled with his own, with the ground black on his side of the hatchment, and white on hers, to distinguish the dead from the living.

A *Wife*, her arms as before on the ground on her side, black, and white on her husbands; has a shell instead of a crest.

A *Widower*, has his arms impaled with those of his wife, ground all black with a crest.

A *Widow* has her arms impaled with her husbands, within a lozenge shield; has ground all black, with a shell instead of a crest.

When the deceased is the *last of a family*, instead of a crest or shell, a death's head is used, thus significantly denoting the universal empire of the king of terrors. The little shields placed on the foreheads of horses drawing hearses are called *chaperones*.

Arms, are all those figures and characters with which the field of the escocheon is charged, and they express the degree, merit, and quality of the original bearers.

Augmentations, given as particular marks of honour, are additional charges borne on an escocheon.

Baron is derived from the Latin *baro*, which was used in the pure age of that language for *vir*, a valiant man; whence those placed next the king in battle, were called *barones*, as being the bravest men in the army; and as princes frequently rewarded the bravery and fidelity of those about them, the word was used for any noble person who held a fee immediately from the king.

Baron is more particularly used in England for a lord, or peer of the lowest class; or a degree of nobility next below that of a viscount, and above that of a knight, or baronet. Barons are lords of parliament, and peers of the realm, and enjoy all the privileges thereof. *The coronet of a baron has only four pearls.*

Baronet is a dignity, or degree of honour next below a baron, and above a knight: a baronet has precedency of all knights, except those of the Garter.

The dignity of baronet is given by patent, and is the lowest degree of hereditary honour. The order was founded by James I. instead of knights bannerets. They had considerable privileges given them. Baronets take place according to the dates of their patents.

A *Bey* is a governor of a country, or town in the Turkish empire.

Charges are those things which possess the field whether *natural, artificial, vegetable,* or *sensitive.*

Common Charges consist of men, angels, birds, beasts, fishes, &c.

Clarencieux, King-at-arms, so named from Clarence, third son of Edward III.

His office is to marshall the funerals of the lower nobility on the south of the Trent. Hence the Clarencieux *Southroy* or *Surroy* and *Northroy,* or *Norroy,*—being provincial heralds.

A *Commoner* never can impale his arms with those of one of title. They are always placed on separate shields.

A *Coronet* or *crown,* more ancient than the helmet, was invented in token of triumph.

Those most in use are of ten sorts, viz. crowns, coronets, mitres, helmets, mantlings, chapeaux, wreaths, crests, scrolls, and supporters.

Crowns, ornaments for the head, appropriated in the present day to emperors and kings only, were only diadems, bands, or fillets among the Greeks. The Romans had various crowns to reward martial exploits and extraordinary services done the republic.

The crown of the king of Great Britain is a circle of gold bordered with pearls and precious stones, and heightened up with four crosses pattee, and four fleurs-de-lis, alternately; from them rise four arched diadems adorned with pearls which close under a mound surmounted by a cross like those on the circle.

The coronet of the prince of Wales resembles the king's except that it is closed with one arch only, adorned with pearls.

A ducal coronet is a circle of gold bordered with ermine, enriched with precious stones and pearls, and set round with eight large strawberry or parsley leaves.

A marquis's coronet is a circle of gold, with ermine, set round with four strawberry leaves, and as many pearls on *pyramidical* points on equal points alternate.

An earl's coronet is a circle of gold, bordered with ermine, and heightened up with eight *pyramidical* points or rays, on the tops of which are as many large pearls, and are placed alternately with as many strawberry leaves, but the pearls much higher than the leaves.

The eldest sons of peers above the degree of a baron, use the coronet belonging to their father's second title, and bear his arms and supporters with a label; and all the younger sons bear the same arms with the proper difference; but without coronets.

The helmets of sovereigns were of burnished gold, damasked; those of princes and lords, of silver figured with gold; those of knights, of steel adorned with silver; and those of private gentlemen, of polished steel.

Those of the king, royal family, and noblemen of Great Britain are open-faced and grated, and the number of bars denotes the wearer's quality: thus the king's helmet has six bars; dukes and marquisses five; and all other peers only four. The open helmet without bars belongs to baronets and knights, and the closed helmets to esquires and gentlemen.

The chapeau is an ancient hat or cap of dignity, worn by dukes; generally of scarlet velvet on the outside, lined, and turned up with ermine; it is frequently painted above a helmet, instead of a wreath, under noblemen's and gentlemen's crests.

Counts. English counts are distinguished by the title of *earls;* but those of other countries retain their proper name. The dignity of count is between that of duke and baron.

Under Charlemagne all generals, counsellors, judges, and secretaries of cities were counts; the characteristic of a duke and a count was, that the latter had but *one* town under him, but the former *several.* In the Roman commonwealth, *comites* was a general name for those who accompanied the proconsuls and pro-prætors into the provinces. Under the emperors the *comites* were officers of the palace. Counts seem to derive their origin from Augustus, who took several senators to accompany him in his voyages and travels, and to assist him in hearing causes, which were determined with the same authority as in full senate. Gallienus abolished this council. Constantine converted the title count into a dignity. The name once established, was soon conferred on most officers. Under the last of the second race of French kings, the dignity was rendered hereditary; and even usurped the sovereignty, when Hugh Capet came to the crown. His authority was not sufficient to oppose the encroachments of the counts, and hence the privilege of wearing coronets in their arms is dated. They assumed it as enjoying the rights of sovereigns in their districts. But by degrees, most of the counties became united to the crown.

Crest, the most elevated part of the head-armour, is derived from *crista*, a cock's comb.

It was originally a protection from the edge of the sword, when aimed at the upper part of the skull. The knights who celebrated jousts or tournaments wore plumes of the heron and ostrich feathers, with crests of various materials.

Czar, a Russian title given to an emperor. *Czar* or *Tzar* is a corruption of *Cæsar*.

Dey, the title of the Algerine sovereign, denotes *uncle*. The emperor is father, the empire mother, the dey is brother of the empire, and consequently *uncle*.

The *Doge* of Venice is the chief magistrate, and his title is equivalent to *duke*.

Duke is a title of nobility next below a prince.

In England, during the Saxons, the officers and commanders of armies were called *dukes*, after the manner of the ancient Romans *Dux-Duces*. After the Conqueror's time the title lay dormant, till Edward III. created his son, Edward, duke of Cornwall. More dukes were afterwards made, whose titles descended to posterity.

The dukes of our days retain nothing of their ancient splendour or sovereignty but the coronet on their escocheon. They are created by patent, cincture of the sword, mantle of state, imposition of a cap, and coronet of gold on the head, and a verge of gold in their hand. The eldest sons of dukes are, by courtesy, styled *marquisses*, and the younger *lords*. A duke has the title of *grace*; and, being written to, is styled, in the herald's language, most high, potent, and noble prince. Dukes of the blood royal are *most high, most mighty*, and *illustrious princes*. The coronet of a duke is distinguished by being adorned with *strawberry leaves*.

Earl is an English title of honour next below a marquis, and above a viscount. Earls were anciently attendants of the king in his councils, and martial expeditions; as *comites*, (counts) were of the magistrates of Rome. Hence, also, earls are called in Latin *comites*; in French *comtes*, &c.

The Germans call them *grave*, as landgrave, margrave, palsgrave, &c. the Saxons, *eoldermen*: the Danes, *earles*; and the English, *earls*. The title died with the possessor till William the conqueror made it hereditary, giving it in fee to his nobles; and annexing to it a shire or county. Earls are now created by charter, without any particular relation to counties; and without any profit except some honorary stipend out of the exchequer. An earl is created by cincture of sword, mantle, a cap, and a coronet put on his head, and a charter in his hand. They are styled our cousins by the king. Their title is, *most noble and potent Lord*. The coronet of an earl has the pearls raised above the leaves.

Earl-marshal,—one of the great officers of the crown, takes cognizance of all matters touching honour and arms; determines all questions and differences that arise between heralds and other persons, concerning pedigrees, honour, arms, crests, supporters, and armorial ensigns.

He bears a staff of gold tipped with black, having the king's arms enamelled on one end, and his own at the other, and takes his place with the lord great chamberlain. Assisted by the kings and heralds, he marshals and orders the proclamation and coronation of kings; marriages, christenings, funeral obsequies, cavalcades, royal interviews and feasts.

Emperor, among the Romans signified a general of an army; afterwards it denoted an absolute monarch. It is pretended that the *imperial* dignity is more eminent than the *regal*; the greatest and most absolute monarchs, however, as those of Babylon, Persia, Assyria, and Egypt, were *kings*.

In the east, the title and quality of an emperor are more frequent than in the west. In 1723 the czar of Muscovy assumed the title of *emperor of Russia*. The king of England had anciently the title of *emperor*, as appears from a charter of king Edgar. The crown of England has been declared in parliament, an imperial crown; and since the union with Ireland, parliament is styled an "*imperial parliament*."

Ermine signifies black spots on a white field, if the word *plain* be used, it denotes nothing but white furs. It is supposed to represent the skin of an animal of the same denomination.

There is no animal whose skin naturally corresponds with the herald's ermine. The animal is milk-white; and so far is it from being spotted, that it will rather die than sully its whiteness; whence its symbolical use. White skins were, for many ages, used for the robes of magistrates, and great men. But the furriers at length, to add to their beauty, sewed bits of black upon the white, to render them more conspicuous.

Escocheon, or shield is the principal surface on which the emblems are painted. *Accidents* in the escocheon are points and abatements.

There are nine points in an escocheon: three on the upper part, of which the middle one is the *chief;* that in the right corner the *dexter chief;* and that in the left corner the *sinister chief.* Three perpendicularly in the middle part of the shield: the first, named the *honour point;* the second, the *fess point;* the third, the *navel point.* Three points horizontally at the bottom: the middle one called the *base point;* the other two the *dexter*, and sinister base points. *Tinctures* are armorial colours; of them there are nine.

1. *Or*, gold, represented on copper-plate prints by small points.
2. *Argent*, silver without any points, by the whiteness of the paper.
3. *Azure*, hatches or strokes from side to side across the shield.
4. *Gules*, line from top to bottom.
5. *Sable*, hatches crossing each other.
6. *Vert*, from dexter chief to sinister base.
7. *Purpure*, from sinister chief to dexter base.
8. *Tennee*, cross hatches from right to left, and from left to right.
9. Sanguine, hatches, from right to left, and others from side to side.

Esquire was originally the person who, attending a knight in the time of war carried his shield: whence he was called *escuier* in French.

Those called esquires by the French, were military vassals, with liberty to wear a shield, the ensigns of their family, in token of their gentility. It is now considered merely as a title of dignity, and next in degree to a knight. Officers of the king's court and household, counsellors at law, justices of the peace, are only esquires in reputation: and he who is a justice of the peace, has this title only during the time he is in commission, and no longer, if he be not otherwise qualified to use it. A sheriff of a county, being a superior officer, bears the title of esquire during his life. The chiefs of some ancient families are esquires by prescription; and in the late acts of parliament, many wealthy persons, commonly reputed to be such, were ranked among esquires.

Furs are of different kinds, and represent the hairy skins of animals, prepared for the linings of robes of state; shields were anciently covered with furred skins; they are used in coats of arms.

Garter, principal king-at-arms, is an officer constituted by Henry V. with the advice and consent of the knights of the garter, for their service; and his duty is to perform whatever the sovereign, prelate or chancellor of the order shall enjoin.

This officer, as principal herald, or king of arms in England, (as *Lien* is in Scotland, and *Ulster* in Ireland), marshals the solemn funerals of princes, dukes, marquisses, earls, viscounts, and barons.

Gentleman, is a term applied to a person of good family, or descended of a family which has long borne arms. J. Kingston was made a gentleman by king Richard II.

If it be asked, What constitutes a gentleman? the answer is—*being entitled to bear arms.* The distinction between a gentleman of coat armour, or an upstart, and a gentleman of blood, is the bearing arms from the grandfather, he who bears arms from his grandfather, is a gentleman of blood; it is requisite, by the statutes of the *Bath,* that every knight, before his admission, prove his qualifications. If a gentleman be bound apprentice to a merchant, or trader, he does not lose his gentility.

But the word *gentleman* is a general term for persons of education and respectable appearance. The French *gentilhomme,* the Italian *gentilhuomo,* and the Spanish *hidalgo,* imply rather persons of fashion.

Heralds, in former times attended their sovereigns in their wars abroad; and in their progress, were often dispatched to other princes, with messages of war, as defiances, &c. and if they received any violence, or affront, it was resented by their master.

Their business was to determine peace and war, leagues and agreements, and to proclaim them. They were also employed at jousts and tournaments; and noblemen, as well as princes, had their heralds and pursuivants.

The herald's college is situated upon St. Bennet's-hill, near Doctors'-commons, and was the ancient house of Thomas Stanley, earl of Derby, who married Margaret countess of Richmond, mother of Henry VII. and the duke of Norfolk having, in lieu thereof, exchanged lands with the crown, he procured the same to be bestowed by queen Mary on the king's heralds and pursuivants of arms for ever, that they might assemble, and preserve their records in this place. Since the fire of London it has been rebuilt; and has a large room for keeping the court of honour, with a library, houses, and apartments for the officers.

King,—A monarch who reigns *singly* over a people. The word is from the Saxon. Among the Greeks and Romans, kings were priests as well as princes.

The king of the Romans was a prince chosen by the emperor; as a coadjutor in the government of the empire. In all public letters the king styles himself *nos*, we; though in the time of king John he spoke in the singular number.

Knight, signifies a person, who, for his virtue and martial prowess is, by the king, raised above the rank of gentleman, into a higher class of dignity and honour.

Knighthood was the first degree of honour in the ancient armies, and was conferred, with much ceremony, on those who had distinguished themselves by valourous exploits. They were originally *adopted,* which we now call *dubbed;* as being supposed, in some measure, the sons of him who knighted them. The ceremonies at the creation of a knight have been various. The principal were a box on the ear, and a stroke with a sword on the shoulder. A shoulder belt, a gilt sword, spurs, and other military accoutrements, were put on, after which, being armed as a knight, he was led in great pomp to the church.

Knights Errant, were a pretended order of chivalry, repeatedly mentioned in romance. They were heroes, who travelled in search of adventures, to redress wrongs, rescue damsels, and take all occasions to signalize their prowess. This romantic bravery of the old knights was formerly the chimera of the Spaniards; among whom every cavalier had his mistress, whose esteem he was to gain by some heroic deed. The duke of Alva is said, to have vowed the conquest of Portugal to a young lady. But the romance of Don Quixote very successfully ridicules the adventures of these heroes, and considerably reduces their number.

Knights of the shire, or *knights of parliament*, are two gentlemen chosen on the king's writ by such of the freeholders of every county, as can expend 40s. per annum, to represent such county in parliament. They must have at least 600l. per annum, and their expences are to be defrayed by the county, though this is seldom now required.

Knights Bachelors were the lowest order of knights, and inferior to bannerets. They are called *equites aurati;* from the gilt spurs put on them at creation. The ceremony is exceedingly simple; the king touches him lightly with a naked sword, and says, *Sois chevalier, au nom de Dieu;* and afterwards, *avance chevalier.*

Knights Bannerets, an ancient order of knights, or feudal lords, who possessing several large fees, led their vassals to battle under their own flag or banner. He had the power to raise a certain number of armed men, with an estate sufficient to subsist about thirty men. Bannerets second to none, save knights of the garter, were reputed next below the nobility. In England the title died with the persons that gained it. The last person created banneret was Sir John Smith, made so after the battle of Edgehill, for rescuing the standard of king Charles I.

Knight of the Garter. When a knight of the garter marries, his wife's arms are placed in a distinct shield, because his own arms are surrounded with an ensign of the order; though the husband may give her his equal share of the shield and hereditary honour, he cannot share his temporary order of knighthood.

Lord is a title of honour, attributed to those who are deemed noble, either by birth or creation, and vested with the dignity of baron. This word of Saxon origin, signifies *bread-giver*: alluding to the hospitality of our ancient nobles.

In the above sense, lord amounts to peer of the realm, lord of parliament. It is also applied to those so called by courtesy, as sons of a duke, or marquis, and the elder son of an earl. The appellation is also given to some persons honourable by office; as lord chief justice, lord chancellor, lord of the treasury, &c.

A *Mantle*, is the drapery thrown around a coat of arms, and doubled or lined throughout by fur.

Marshal, or *Mareschal*, primarily denotes a person who has the care of horses. *Marshal of France*, the highest dignity of preferment in the French armies, under the old monarchy, was abolished at the revolution, but has since been revived, and is now used in the armies of Europe.

By *Marshalling* coats of arms, is to be understood the art of disposing several of them in one escocheon, and of distributing their contingent ornaments in their proper places.

When the coats of arms of a married couple, descended of distinct families, are to be marshalled on an escocheon, the field of their respective arms is conjoined pale-ways, and blazoned thus: parted per pale, baron and femme; first the baron's arms are to be described, then the femme's. The baron's arms are always to be placed on the dexter, and the femme's on the sinister side of the escocheon. This is the case only when the femme is not an heiress.

Baron and *femme* are heraldic terms for husband and wife.

If a widower marry again, his late and present wife's arms are to be both marshalled on the sinister side in the same escocheon with his own, and parted per pale.

Thus the first wife's shall stand on the chief, and the second on the base, or they may both be in pale with his own; the first wife's coat next to himself, and those of the second outermost.

If he marry a third wife, then the arms of his two first shall stand on the chief, and those of the third on the base; if a fourth, she must participate one half of the base with the third wife, and so will they appear to be so many coats quartered.

These forms of impaling are applied only to hereditary coats, whereby the husband stands in expectation of having the hereditary possessions of his wife united to his own patrimony.

If a man marry a widow, he marshals her maiden arms only.

When the arms of femmes are joined to the paternal coat of the baron, the proper differences, such as the label, the crescent, &c. borne by the fathers of such women must be inserted.

If a coat of arms that has a bordure, be impaled with another, the bordure must be wholly omitted in the side of the arms next the centre.

The person who marries an heiress, instead of impaling his wife's arms with his own, is to bear them in an escocheon placed in the centre of his shield; and as this denotes his pretensions to her estate, it is called an escocheon of pretence, and is blazoned *surtout*.

The children of such marriages bear the hereditary coat of arms of their father and mother quarterly, which denotes a fixed inheritance, and transmit them to posterity.

These arms are marshalled thus; the first and fourth quarters generally contain the father's arms, and the second and third the mother's; unless the heirs should derive not only their estates, but also their title and dignity from their mother.

If a maiden, or dowager lady of quality marry a commoner, or a nobleman inferior to her rank, their coats of arms may be set beside one another in two separate escocheons, upon one mantle or drapery, and the lady's arms ornamented according to her title.

Archbishops and bishops impale their arms differently from those before mentioned, as they give the place of honour, or dexter side, to the arms of their dignity or see. Prelates bear their arms parted per pale, to denote their being joined to their church by a kind of spiritual marriage.

With respect to such armorial ensigns as a sovereign shall think fit to augment a coat of arms with, they may be marshalled various ways, by heralds whose peculiar office it is.

The baronet's mark of distinction, is the arms of the province of Ulster, in Ireland; granted and made hereditary in the male line by king James the First, who created this dignity on the 22nd of May, 1611, in the seventh year of his reign. Argent, a sinister hand couped at the wrist, and erected, gules, borne either in a canton, or in an escocheon, as may best suit the figures of the arms.

Marquis, a title next below a duke, is derived by some from the Marcomanni, an ancient people, who inhabited the marches of Brandenburg. Marquisses were anciently governors of frontier cities, or provinces, called marches.

Marquis is originally a French title. Richard II. first introduced the dignity of marquiss into England. The coronet of a marquiss has strawberry leaves and pearls placed alternately.

Monseigneur, in the plural *monseigneurs*, a title of honour and respect formerly used by the French in writing to persons of superior rank, or quality, is a compound of *mon*, my, and *seigneur*, lord.

Dukes, peers, archbishops, and bishops, were complimented with the title *monseigneur*. In the petitions presented to the sovereign courts, they use the term *nos seigneurs*. Monseigneur, absolutely used, was a title afterwards restrained to the Dauphin of France.

Monsieur, in the plural *messieurs*, a term used by the French in speaking of their equals; answers to Mr. or Sir, in English. The word is a compound of *mon*, my, and *sieur*, sir.

The Italians say *signor*, and the Spaniards *senor*, in the same sense, and from the same origin. The superscription of all letters began, à *monsieur*, *Monsieur* such a one. The word *monsieur*, formerly extensive, was applied to persons who had been dead for ages, *monsieur* St. Augustine, *monsieur* St. Paul, &c. &c.

A *Motto*, is some word or sentence indicative of the quality of the bearer; or it conveys some peculiar and important truth.

They are chosen at the fancy of the owner; sometimes they consist of a religious or moral sentiment, as "*Murus æreus conscientia sana*;" A good conscience is a wall of brass! Sometimes an effusion of loyalty; sometimes a love of liberty, as the earl of Radnor's is, "*Patria cara carior libertas*;"—My country is dear, but liberty is dearer. As "*Miseris succurrere disco*," I learn to succour the distressed; "*Sola nobilitat virtus*;" Virtue alone ennobles us.

Nobility. The peerage of England is of five degrees, viz. that of duke, marquis, earl or count, viscount, and baron.

The term of *nobility* is, in England, restrained to degrees of dignity above knighthood. Some refer the origin of nobility to the Goths, who, after they had seized a part of Europe, rewarded their captains with titles of honour, and called them nobles, (*nobiles*) to distinguish them from the common people. In England, nobility is only conferred by the king, and that by patent. In other countries there are other ways of acquiring it. The privileges of the English nobility are very considerable; they are esteemed as the king's hereditary counsellors, and are privileged from arrests, unless from treason, felony, and breach of the peace. In criminal cases they are only to be tried by a jury of peers, who are not put to their oaths. They give their verdict upon their honour. In their absence, they are allowed a proxy to vote for them.

Norroy king of arms, marshals the funerals of all the inferior nobility, as baronets, knights, esquires, and gentlemen, on the north side of the Trent.

A *Prince*, is a person invested with the command of a state or country, independent of any superior. It is used for one sovereign of his own territory, who yet acknowledges some other as his superior, and pays homage to him.

Thus, all the princes of Germany are feudatories of the emperor: though as absolute in their respective principalities as the emperor himself, yet are they bound to him in certain services. Prince is a title given to the issue of princes, or those of the royal family; in which sense those of France were called *princes of the blood*. In England, the eldest son is created prince of Wales; the younger, dukes or earls, with what title the king pleases. To all the king's children belongs the title of *royal highness*. All subjects are to kneel when admitted to kiss their hand: and at table, out of the king's presence, they are served on the knee. The youngest sons and daughters of the king have precedence of all peers and public officers, ecclesiastical and temporal. The prince of Wales is born duke of Cornwall and Rothsay, and immediately entitled to all the rights, revenues, &c. belonging thereto. He is afterwards created prince of Wales, and earl of Chester, &c.

Pursuivant, the lowest order of officers at arms. They are, properly, attendants on the heralds, when they marshal public ceremonies.

Of those, in England, there were formerly many; but at present only four, viz. *blue-mantle*, *rouge-cross*, *rouge-dragon*, and *port cullice.* In Scotland, there is only one king-at-arms styled *Lyon*, who has under him no less than six heralds, as many pursuivants, and a great number of messengers-at-arms.

Quartering, is the proper disposition of the coat-armour of distinct families within one escocheon; as on account of marriage, when the arms of man and wife are conjoined together paleways. This is called impaling *baron and femme.*

When children are born, the baron bears the arms of the *femme*, she being an inheritrix, in an inescocheon. The heir may bear his mother's arms quartered with his own. An augmentation of honour and arms is frequently acquired by adoption. By the gift or munificence of the sovereign, a person bears his own coat, together with the new ensigns of honour.

Sire, a title in France given to the king, as a mark of sovereignty, was anciently used in the same sense with *sieur* and *seigneur*, and applied to barons, gentlemen, and citizens. *Sieur* having been a title of honour among the French, the lawyers would say, I plead for the *sieur* marquis, the *sieur* abbot, &c. for *sieur* often expressed *seignory* or *lordship.*

Stadtholder was a title formerly given to the governor or lieutenant of a province in the United Netherlands; particularly that of Holland, where the word has been chiefly used. It is derived from the word *stadt*, state, and *houlder*, holding, which is, lieutenant of the states.

This title is now absorbed in that of king; the prince of Orange being now king of the Netherlands.

Sultan, a title given to the emperor of the Turks, had its rise under *Mahmoud.*

The word is Turkish, and signifies *king of kings*, and was first given to the Turkish princes about the year 1055. The title has ever since been used by all mahommedan princes. The highest officer, among the Turks, next to the sultan, is the *grand vizier*, who has the care of the whole empire. He lives in the utmost splendour, having more than two thousand officers and domestics in his palace.

Supporters are figures by the side of a shield, appearing as if they actually held it erect.

They use chiefly figures of beasts: figures of human creatures for the like purpose, are called *tenants*. In England, none under the degree of banneret are allowed supporters, which are restrained to those called the high nobility.

Since the accession of king James the First, the supporters of the arms of Great Britain are placed on the dexter side, a lion rampant gardant, crowned *or*; and on the sinister side, a unicorn argent, crowned, armed, unguled, maned and gorged, with an antique crown, to which a chain is affixed, all *or*.

A lion is said to be rampant when he stands erect on his hind legs, and rampant gardant, when in that position his head is turned sideways; passant, and passant-gardant when he is walking; couchant when he is lying down, &c. A stag, when briskly walking, is said to be tripping; when running, courant; when standing still, at gaze, &c.

A creature is said to be armed when its horns, beak, talons, &c. are of a different tincture from the rest of the body; thus the horn of the unicorn is *or*, while his body is *argent*.

Thane, a dignity among the English, or Anglo-Saxons, is referred to king Canute, who taking the chief of the Danish nobility, to the number of 3000, for his guard called them *thing-lethe*, from two Danish words, *theing* or *thein*, both of nobility, and *lith*, order of battle. In old English authors, *thane* signifies a nobleman; sometimes a freeman, and sometimes a magistrate.

Viscount, a term used for a degree of nobility next below a count or earl, and above a baron; is supposed to have been brought hither by the Normans. The coronet of a viscount is surrounded with pearls only.

Wreath, a roll of silk, of two colours, blazoned on the shield, and laid on the helmet, as a support to the crest.

SECTION III.

DEGREES OF PRECEDENCY, AND DIFFERENT KINDS OF ARMS.

313. The King.
Princes of the Blood.
Archbp. of Canterbury.
Lord High Chancellor.
Archbishop of York.
Lord Treasurer.
Lord President of the Council.
Lord Privy Seal.
Dukes.
Eldest sons of Dukes of the Blood Royal.
Marquisses.
Eldest sons of Dukes.
Earls.
Marquisses' eldest sons
Dukes' younger sons.
Viscounts.
Earls' eldest sons.
Marquisses'youngersons.
Bishops.
Barons.
Speaker of the House of Commons.
Lord Commissioner of the Great Seal.
Viscounts' eldest sons.
Earls' younger sons.
Barons' eldest sons.
Privy Councellors not Peers.
Chancellor of the Exchequer.
Chancellor of the Duchy.
The Knights of the Garter not Peers.
Lord Chief Justice of the King's Bench.
Master of the Rolls.
Lord Chief Justice of the Common Pleas.
Lord Chief Baron of the Exchequer.
Puisne Judges and Barons.
Knights Banneret, if made in the field of battle.
Master in Chancery.
Viscounts' younger sons.
Barons younger sons.
Baronets.
Knights Banneret.
Knights of the Bath.
Knights Bachelors.
Baronets' eldest sons.
Knights' eldest sons.
Baronets' younger sons.
Knights' younger sons.
Field and Flag officers.
Doctors graduate.
Serjeants at Law.
Esquires.
Gentlemen.
Yeomen.
Tradesmen.
Artificers.
Labourers.

The ladies, except those of archbishops, bishops, and judges, take place according to the quality of their husbands, and unmarried ladies take place according to that of their fathers.

314. The different kinds of arms are distinguished by different names, to denote the causes of their bearing; such as arms of dominion, of pretension, of concession, of community, of patronage, of family, of alliance, of succession, of assumption.

Arms of dominion and sovereignty are borne by emperors, kings, and sovereign states; being, as it were, annexed to the territories, kingdoms, and provinces, they possess. Thus, there are the arms of England, of France, of Spain, &c.

Arms of pretension belong to kingdoms, provinces or territories, to which a prince or lord has some claim, and which he adds to his own, although possessed by another.

Arms of concession, or *augmentation* of honour, are arms, or figures, given by princes, as in reward of some signal service.

Thus, Lord Heathfield, who so gallantly defended Gibraltar, was permitted to assume that fortress on his escutcheon in additon to his family arms.

Arms of community belong to bishopricks, cities, universities, societies, companies, and corporate bodies.

Arms of patronage belong to governors of provinces, lords of manors, patrons of benefices, &c. as a token of their superiority, rights, and jurisdiction.

These arms have introduced into heraldry, castles, gates, wheels, ploughs, &c. &c.

Arms of family or paternal arms, belong to one particular family, and distinguish it from others; these it is criminal for any other person to assume, and punishable by the sovereign authority.

Arms of alliance belong to families and private persons, to denote the alliance they have contracted by marriage.

This kind of arms is either impaled or born in an escutcheon of pretence, by those who have married heiresses.

Arms of succession are taken up by those who inherit certain estates, manors, &c. either by will, *entail*, or *donation*, and which they either impale or quarter with their own; this multiplies the titles of some families from necessity, and not from *ostentation*, as many imagine.

Arms of assumption, or assumptive arms, are taken up by the caprice or fancy of upstarts of mean extraction, who, on becoming persons of fortune, assume them without a legal title.

CHAPTER XIV.

THE NATURE AND PROPERTIES OF FIRE.

SECTION I.

GENERAL PRINCIPLES.

315. WHENEVER you perceive a number of qualities always existing together, you are warranted to conclude that there is some substance which produces those qualities.

Fire drives out other bodies from any given space, it has a constant tendency to diffuse itself uniformly, so as to maintain an equilibrium, it dilates some substances; it must have penetrated them; it expels other bodies and takes their place; therefore we conclude it must itself be a body—*a real and material substance.*

Air is a *substance* and not a *quality.* People who are unacquainted with the principles of natural philosophy, would not suppose that the air by which we are surrounded is a material substance, like water, or any other visible matter. Being perfectly invisible, and affording no resistance to the touch, it must seem to them extraordinary, to consider it as a solid and material substance; and yet a few simple experiments will convince any one that it is really matter, and possesses weight, and the power of resisting other bodies that press against it. And it differs from all other fluids in the four following particulars :—1. It can be compressed into a much less space than what it naturally possesses ; 2. It cannot be congealed, or fixed, as other fluids may ; 3. It is of a different density in every part upward from the earth's surface, decreasing in its weight, bulk for bulk, the higher it rises ; 4. It is of an elastic, or springy nature, and the force of its spring is equal to its weight.

Fire in common with air is subject to these laws.

Light is an emanation of fire ; the decomposition of the rays of light proves its materiality ; what is light on the surface of a burning glass is fire at its focus ; whatever, therefore, proves the materiality of light is applicable to fire.

We conclude, therefore, that fire is a real and material substance ; and by the word fire we mean that very subtil fluid which all men call fire ; heat is an *effect* of fire, or a proof of its presence ; *absolute heat* and fire are words of the same import ; *relative heat* is an epithet applied to the measured effects of fire.

Fire penetrates all bodies, even the hardest ; and one of its most constant characters is a continual tendency to equilibrium, or to flow from a warmer to a colder substance.

316. *Heat,* considered as a sensation, or, in other words, sensible heat, is only the effect produced upon our organs by the motion of *caloric,* disengaged from the surrounding bodies. In general, we receive impressions only in consequence of motion, and it might be established as an axiom, that *without motion there is no sensation.*

This general principle applies very accurately to the sensations of heat and cold. When we touch a cold body, the caloric, which always tends to become in equilibrio in all bodies, passes from our hand into the body we touch, which gives us the feeling or sensation of cold. The contrary happens when we touch a warm body ; the caloric then, in passing from the body into our hand, produces the sensation of heat. If the hand, and the body touched be of the same temperature, or very nearly so, we receive no impression either of heat or cold, because there is no motion or passage of caloric.

When the thermometer rises, it shews that the free caloric is entering into the surrounding bodies. The thermometer, which is one of these, receives it in proportion to its mass, and to the capacity which it possesses for containing caloric.

317. *Free Caloric* is that which is not combined, in any manner, with any other body. But as we live in a system, to the matter of which caloric has a very strong adhesion, we are never able to obtain it in the state of absolute freedom.

Combined caloric is that which is fixed in bodies by affinity, or elective attraction, so as to form part of the substance of the body.

By the expression *specific caloric* of bodies, we understand the respective quantities of caloric requisite for raising a number of bodies, of the same weight, to an equal degree of temperature. This proportional quantity of caloric, depends upon the distance between the constituent particles of bodies and their greater or less degrees of cohesion; and this distance, or rather the space or void resulting from it, is called the *capacity of bodies for containing caloric.* The fluid of caloric constantly tends to form an equilibrium, by diffusing itself through all bodies. It is extremely subtil, and its gravity cannot be ascertained.

318. Bodies which transmit caloric easily, are called *conductors* of caloric, and according to the power of doing this, they are termed good or bad conductors. Those which do not transmit heat at all, or with great difficulty, are called *non-conductors.*

The best conductors of heat are metals; and the best non-conductors are fluids, such as water and air, also charcoal. Heat is produced in various ways; by collision, by friction, by chemical action, by the solar rays, by electricity, and galvanism.

The simplest method of obtaining heat, is by collision, and is the method generally employed in the common way of making a fire. When a piece of hardened steel is struck with a flint; some particles of the metal are broken off, and so violent is the heat produced by the stroke, that they are rendered red-hot, melted, and even vitrified. If the fragments of the steel be caught upon a piece of white paper, and examined with a microscope, they will be found to be spherules, and highly polished. Their sphericity proves them to have been in a fluid state, and the polish upon their surface, shews that they have been vitrified.

No heat seems to follow from the percussion of liquids, or of soft bodies.

Heat may be excited by mere friction, and this method of procuring it is still practised in some parts of the world. The American Indians produce it in this manner with great dexterity. For this purpose they take two pieces of dry wood, one about eight or nine inches long, and the other piece quite flat. They cut a blunt point upon the first, and pressing it upon the other piece, they whirl it round very quickly, holding it between both their hands, as we do a chocolate-mill. In a few minutes the wood takes fire.

If the irons at the axis of a coach-wheel be left without grease or oil, they will become so hot, as to set fire to the wheels; and accidents of this kind frequently happen.

It is no uncommon practice in the country, for a blacksmith to hammer a piece of iron till it becomes red-hot, as a substitute for a tinder-box. The heat excited by the boring of a cannon is sufficient to cause water to boil.

Under the production of heat by chemical action is included that by combustion. Heat is also produced by the mixture of many cold substances, but the most intense heat that is known is produced by thowing a stream of oxygen gas upon lighted charcoal.

It is well known that the *solar rays*, when collected by a mirror, or lens, produce the most astonishing effects,

Dr. Herschel has lately proved, that the solar rays consist of two kinds, those which produce light, and others that produce heat, which can be separated from each other by the prism.

319. The instruments for measuring heat by the expansion of bodies, are *thermometers* for fluids, and *pyrometers* for solids.

A thermometer is a hollow tube of glass, hermetically sealed, and blown at one end into the shape of a hollow globe, or bulb. The bulb, and part of the tube, are filled with mercury, which is the only fluid that expands equally. When we immerse the bulb of the thermometer in a hot fluid the mercury expands, and of course rises in the tube;

but when we plunge it into a cold body, the mercury contracts, and of course *falls* into the tube. The rising of the mercury, therefore, indicates an increase of heat; its falling, a diminution of heat. To facilitate the observation, the tube is divided into a number of equal parts, called degrees, or there is a divided scale attached to it.

This scale is graduated in different manners: Fahrenheit's scale is that always used in this country.

The standard-points are obtained by freezing and boiling water, degrees of heat which are constantly the same in nature. The heat at which the mercury stands, when immersed in each, being marked, the distance between them is divided into 180 parts, and 32 parts of the same size are continued downwards, so that 32° shew the heat of freezing water, and 212° that of boiling water. Water cannot be made hotter than this in open vessels, because it then becomes converted into *steam*, or *aqueous* gas.

The mercurial thermometer, it is evident, cannot measure degrees of heat above that of boiling mercury, nor below that of freezing mercury; the former is 600°, and the latter 40° below 0 of Fahrenheit's scale.

For greater degrees of cold, thermometers of spirits of wine, or essential oil are used: and to measure those higher degrees of heat to which the thermometer cannot be applied, *pyrometers* are employed.

Wedgewood's pyrometer consists of two pieces of brass, fixed so as to form an angle, having the legs divided into equal parts. Pieces of baked clay are prepared for this scale, so as to fit the brass at a certain place. If then the piece of clay be exposed to the heat required to be examined, it will contract in its dimensions, and when again applied to the brass scale, it will be seen how much it has contracted. By this the intensity of the heat is ascertained, for the clay of which these pieces are prepared has the property of contracting regularly, according to the degree of heat.

This is an exception to the general law of bodies expanding by heat; the expansion of melted metal in the act of cooling is another, as likewise the expansion of water in the act of freezing.

320. The greatest degrees of heat which are known, have been produced by concentrating the solar rays with a mirror, or lens, or by supplying a blow-pipe

with oxygen gas. The greatest degree of cold known to have been produced, has been obtained by mixing snow with certain salts, as muriat of lime. If this be mixed with dry, light snow, and stirred well together, the cold produced will be so intense, as to freeze mercury in a few minutes. Salt and snow also produce a great degree of cold.

Evaporation likewise produces cold. The method of making ice artificially in the East Indies depends upon this principle. The ice makers at Benares dig pits in large open plains, the bottom of which they strew with sugar canes, or dried stalks of maize, or Indian corn. Upon this bed they place a number of unglazed pans, made of so porous an earth, that the water oozes through their substance. These pans are filled towards the evening, in the winter season, with water which has been boiled, and are left in that situation till morning, when more or less ice is found in them, according to the temperature of the air; there being more formed in dry and warm weather, than in cloudy weather, though it may be colder to the human body.

Every thing in this operation is calculated to produce cold by evaporation; the beds, on which the pans are placed, suffer the air to have a free passage to their bottoms, and the pans constantly oozing out water to their external surface, are cooled by the evaporation of it.

In Spain, they use a kind of earthen jars, called buxaros, the earth of which is so porous, being only half baked, that the outside is kept moist by the water which filters through it; and, though placed in the sun, the water in the jar becomes as cold as ice.

It is a common practice in China, to cool wine or other liquors, by wrapping a wet cloth round the bottle, and hanging it up in the sun. The water in the cloth evaporates, and thus cold is produced.

Experiment. Ice may be produced at any time, by the evaporation of ether. Take a thin glass tube, four or five inches long, and about two or three-eighths of an inch in diameter, and a two ounce bottle of ether, having a tube drawn to a point, fitted to its neck. Pour some water into the glass tube, and let a stream of ether fall upon that part of it containing the water, which, by that means, will be converted into ice in a few minutes. If a thin spiral wire be introduced into the tube before the water is poured in, the ice will adhere to it, and may be drawn out.

Caloric is thrown off from bodies in straight lines, in the same manner as light; and is capable of being reflected, and collected into a focus by means of mirrors. If a heated body, as a ball of iron, be placed opposite to a large concave mirror, a thermometer held in the focus of the mirror, will rise immediately. If some ice be put in the place of the ball, the thermometer will fall, seeming to prove that cold is something positive and real, and not merely the absence of heat; but this is explained by philosophers upon the same principle, and is not considered by them as a proof, that cold, like heat, is a distinct substance.

SECTION II.

MISCELLANEOUS PHENOMENA.

Effects of Intense Cold.

321. In Iceland the thermometer frequently falls to zero, which is thirty-two degrees below the freezing point. At Hudson's Bay it has been known to sink even fifty degrees lower. When stones or metals, which have been exposed to such degrees of cold, are touched by the tongue, or the softer parts of the human body, they absorb the heat from those parts with such rapidity, that the flesh becomes instantly frozen and mortified, and the principle of life in them is extinguished. Some French academicians who made a journey to the north of the Baltic, and wintered under the polar circle, found it necessary to use all possible precautions to secure themselves

from the dreadful cold which prevailed. They prevented as much as possible the entrance of the external air into their apartments; and if at any time they had occasion to open a window or door, the humidity of their breath, confined in the air of the house, was condensed and frozen into a shower of snow; their lungs, when they ventured to breathe the cold air, felt as if they were torn asunder; and they often heard the rending of the timber around them, by the expansive power of the frost on the fluid in its pores. In this terrible cold the thermometer fell to 33° *below* zero. The most intense cold ever known in the neighbourhood of London was on December 25, 1796, when the thermometer indicated 2° below zero.

The following narration will show the solidity that water is capable of acquiring when divested of a large portion of its caloric:—During the severe winter of 1740, a palace of ice, fifty-two feet long, sixteen wide, and twenty high, was built at Petersburgh, according to the most elegant rules of art. The river Neva afforded the ice, which was from two to three feet thick, blocks of which were cut, and embellished with various ornaments. When built up, the different parts were coloured by sprinkling them over with water of various tints. Six cannons, made of and mounted with ice, with wheels of the same matter, were placed before the palace; and a hempen bullet was driven by one of these cannon, in the presence of the whole court, through a board two inches thick, at the distance of sixty paces.

" —————————No forest fell,
Imperial mistress of the fur clad Russ,
When thou would'st build;—no quarry sent its stores
T' enrich thy walls; but thou didst hew the floods,
And make thy marble of the glassy wave.
Silently as a dream the fabric rose;
Ice upon ice the well adjusted parts
Were soon conjoin'd; nor other cement ask'd

Than water interfused to make them one.
Lamps gracefully disposed, and of all hues,
Illumined ev'ry side. Long wavy wreaths
Of flowers, that fear'd no enemy but warmth,
Blush'd on the pannels, which were once a stream,
And soon to slide into a stream again."

COWPER.

American Water-burner.

322. This apparatus was invented by Mr. Morey of New Hampshire. The construction is very simple: *tar is intimately mixed with steam or vapour of water, and made to issue, with a force proportional to the pressure of the steam, from a small orifice, like that in the jet of a blow-pipe, and is there fired.* The flame, although the combustible substances issue from so small an orifice, is as large as that of a common smith's forge, and is unaccompanied with smoke; when this flame is directed against the bricks in the back of a fire-place, they soon become heated to redness; if iron or steel filings be thrown into the flame, they burn with a sparkling brilliancy, similar to iron wire in oxygen gas.

A few experiments have been made to ascertain the effect of steam on burning bodies, and to learn whether it probably suffered decomposition when issuing mixed with tar from the jet of the 'Water Burner.'

If a jet of steam, issuing from a small aperture, be thrown upon burning coal, its brightness is increased, if it be held at the distance of four or five inches from the pipe through which the stream passes; but, if it be held nearer, the coal is extinguished, a circular black spot first appearing where the steam is thrown upon it. The steam does not appear to be decomposed in this experiment: the increased brightness of the coal is probably occasioned by a current of atmospheric air produced by the steam.

If the wick of a common oil lamp be raised so as to give off large columns of smoke, and a jet of steam be thrown into the flame, its brightness is a little increased, and no smoke is thrown off.

If spirits of turpentine be made to burn on a wick, the light produced is dull and reddish, and a large quantity of thick smoke is given off; but if a jet of steam be thrown into the flame, its brightness is much increased; and if the experiment be carefully conducted, the smoke entirely disappears.

If vapour of spirits of turpentine be made to issue from a small orifice and inflamed, it burns, giving off large quantities of smoke; but, if a jet of steam be made to unite with the vapour, the smoke entirely disappears. The same effect takes place, if the vapour of spirits of turpentine and of water be made to issue together from the same orifice; hence the disappearing of the smoke cannot be supposed to depend on a current of atmospheric air.

If the flame of a spirit lamp be brought in contact with a jet of steam, it disappears, and is extinguished at the points of contact, precisely as when exposed to strong blasts of air.

Masses of iron of various sizes, and heated to various degrees from redness to bright whiteness, were exposed to a jet of steam: no flame appeared, as was expected, but the iron was more rapidly oxidated where the steam came in contact with it than in other parts. It is probable, if the water suffered decomposition in this experiment, and if the hydrogen was inflamed, its flame might not be observed, when contrasted with the heated iron, a body so much more luminous.

The operation of the water-burner, then, appears to be simply this:—tar, minutely divided and intimately mixed with steam, is inflamed: the heat of the flame aided by the affinity for oxygen of that portion of carbon, which would otherwise pass off in smoke, decomposes the water, and the carbon and oxygen unite; the hydrogen of the water, and probably of the tar, expand on all sides (and hence the flame is very large) to meet the atmospheric oxygen, water is decomposed, and passes off in steam; a degree of heat is produced, no doubt, greater than that which is produced by the combustion of tar alone, and this heat is equal to that evolved by the combustion of a quantity of carbon, which would otherwise form smoke.

Solar Phosphori.

323. A casual discovery by Vincewnio Leascariolo, a shoemaker of Bologna, about 1630, was the first circumstance that attracted the notice of philosophers to this curious subject. This man being in quest of some alchemical secret was induced to calcine a parcel of Bolognian spar (a sub-species of

heavy spar or native sulphat of baryte,) which he had procured from Monte Paterno, in the neighbourhood of the city; and observed, that whenever this substance, thus prepared, was placed in a dark room, after having been exposed to the sun, it continued to emit faint rays of light for some hours afterwards.

In consequence of this interesting discovery, the Bolognian spar came into considerable demand among natural philosophers, and the curious in general, so that the best way of preparing it was found an object of some pecuniary importance. This seems to have been hit upon by the family of Zagoni, who supplied all Europe with Bolognian phosphorus, till the discovery of more powerful phosphoric put an end to their monopoly. Margraaf, some years afterwards, proved that other species of sulphated baryte might, under particular management, be made to produce a similar effect.

In the year 1677, nearly half a century after the discovery of the Bolognian phosphorus, G. A. Baldwin, a native of Misnia, observed, that if nitrat of lime were evaporated to dryness, and then formed into a compact mass by fusion at a red heat, it would exhibit the same property of imbibing and emitting light as the former, only somewhat inferior in degree; hence this preparation obtained the name of Baldwin's phosphorus.

In 1730, M. du Fay, who is justly celebrated for his electrical researches, directed his attention to this subject, and observed, that all earthy substances, susceptible of calcination, either by mere fire, or when assisted by the previous action of nitrous acid, possessed the property of becoming more or less luminous when calcined and exposed for a short time to the light: that the most perfect of these phosphori were lime-stones, and other kinds of carbonated lime, gypsum, and particularly the topaz;

and that some diamonds were also observed to be luminous by simple exposure to the sun's rays, without being previously ignited; while flint, sand, jasper, agate, and rock crystal, were inphosphorescent.

Not long after M. Beccaria discovered that a great variety of other bodies were convertible into phosphori, by exposure to the mere light of the sun; not only the varieties of carburet and sulphat of lime, but organic animal remains, and geodes lined with minute crystals of quartz; most compound salts, when clear and crystallized, particularly Glauber's, nitre, and borax, were also found to be phosphorescent; of vegetable substances all the farinaceous and oily seeds, all the gums, and several of the resins, the white woods, and vegetable fibre, either in the form of paper or linen; also starch and loaf-sugar proved to be good phosphori, after being made thoroughly dry, and exposed to the direct rays of the sun. Sundry animal matters, by a similar treatment, were also converted into good phosphori, particularly bone, either fresh or calcined, sinew, glew, hair, horn, hoof, feathers, and fish shells. The same property, he observed, might be communicated to rock-crystal, and some other of the gems, by rubbing them against each other, so as to roughen their surface, and then placing them for some minutes in the focus of a lens, by which the rays of light were concentrated upon them at the same time that they were also moderately heated.

In the year 1768, Mr. Canton contributed some important facts relative to solar phosphori, and communicated a method of preparing a very powerful one, which, after the inventor, is usually called Canton's phosphorus. It is thus made: Calcine oyster-shells in the open fire for half an hour; then select the widest and largest pieces, and mix them with flower of sulphur in the proportion of one part of the latter to three parts of the former; pack the whole closely in a crucible; lute on a cover, and heat it pretty strongly for one hour; when the crucible has again become quite cold, turn out its contents, and select the whitest pieces for use. Mr. Canton affirms, that his phosphorus, inclosed in a glass flask, and hermetically sealed, retains its property of becoming luminous for at least four years, without any apparent decrease of activity.

Mr. Wilson found that a much greater brilliancy of colour would be produced by letting the oyster-shells come in direct contact with the burning coals, or other inflammable matter, and by being covered with it; and that if the covering matter be iron, the luminousness will be very bright; if steel, still brighter and more iridescent; but if plates of charcoal, most so of all.

If a common box smoothing-iron, heated in the usual manner, be placed for half a minute on a sheet of dry, white paper, and the paper be then exposed to the light, and afterwards examined in a dark closet, it will be found that the whole paper will be luminous, that part however on which the iron had stood being much more shining than the rest.

The Action of Heat aided by Glass.

324. If the rays of the sun dispersed over the surface of a glass, be concentrated in a point, it will thus become a burning lens.

As all the rays which fall upon the lens, are united in its focus, their effect ought to be so much the more, as the surface of the lens exceeds that of the focus. Thus, if a lens four inches broad collect the sun's rays into a focus at the distance of one foot, the mage will not be more than one-tenth of an inch broad. The surface of this little circle is 1600 times less than the surface of the lens, and consequently, the sun's rays must be ten times denser within that circle; it is not therefore surprising, that these rays burn with a degree of ardour and violence exceeding any culinary fire.

The most considerable of these glasses, are those which were made by M. Tschirnhausen and Mr. Parker. The diameter of that of Tschirnhausen was three feet, the focus was formed at twelve feet, and its diameter one inch and a half; it weighed one hundred and sixty pounds. To render the focus more vivid, it was collected a second time, by a lens placed parallel to the first, and so situated, that the diameter of the cone of rays formed by the first lens, was exactly equal to the diameter of the second lens: so that it received all the rays; the focus was contracted to eight lines, and its force was increased proportionally.

The lens made by Mr. Parker, of Fleet-street, London, is formed of flint-glass three feet diameter, and when fixed in its frame, exposes a clear surface of two feet eight inches and a half in diameter; its weight is two hundred and twelve pounds; focal length, six feet eight inches; diameter of the focus, one inch. A second lens was used, which reduced the focus to half an inch.

Some of the principal effects produced by these glasses, were as follow:

1. Every kind of wood took fire in an instant, whether hard or green, or soaked in water.

2. Iron plates grew hot in a moment, and then melted.

3. Tiles, slates, and all manner of earth became red in a moment, and vitrified.

4. Sulphur, pitch, and all resinous bodies, melted under water.

5. Fir-wood exposed to the focus under water, did not seem changed, but when broken, the inside was burnt to coal.

6. If a cavity were made in a piece of charcoal, and the substances to be acted on were put in it, the effect of the lens was much increased.

7. Any metal whatsoever, thus enclosed in the cavity of a piece of charcoal, melted in a moment, the fire sparkling like that of a forge.

8. The ashes of wood, paper, linen, and all vegetable substances, were turned in a moment into a transparent glass.

9. The substances most difficult to be wrought on were those of a white colour.

10. All metals vitrified on a China plate, when it was so thick as not to melt, and the heat was gradually communicated.

11. When copper was thus melted, and thrown quickly in cold water, it produced so violent a shock, as broke the strongest earthen vessels, and the copper was entirely dissipated.

Obs. 1. Though the heat of the focus was so intense as to melt gold in a few seconds, yet there was no heat at a small distance from that focus; and the finger might be placed in the cone of rays within an inch of the focus, without receiving any hurt.

2. Mr. Parker had the curiosity to try what the sensation of burning at the focus was, and having put his finger there for that purpose, he says, it neither seemed like the burning of a fire, nor a candle, but the sensation was that of a sharp cut with a lancet.

3. You may, by means of a burning-glass, char or burn a piece of wood to a coal, in a decanter of water, and yet the sides of the decanter, through which the rays pass so very near the focus, will not be cracked, nor any ways affected; nor will the water be in the least degree warmed. If the wood be taken out, and the rays thrown on the water, no continuance of collected rays in this way, will either heat the water or crack the glass; but if a piece of metal be put into the water, it soon becomes too hot to be touched, and communicating its heat to the water, makes it not only warm, but sometimes causes it to boil.

4. Though water alone be not affected, yet, if a little ink be thrown into it, the water will soon be heated.

SECTION III.

METHODS OF OPERATION BY FIRE.

325. *Evaporation* separates a fluid from a solid, or a more volatile fluid from another which is less volatile.

Simple Evaporation is used when the more volatile, or fluid substance, is not to be preserved.

Various degrees of heat are employed for this purpose, according to the nature of the substances. It is performed in vessels of wood, glass, metal, porcelain, &c. Basons made of Wedgewood's ware are very convenient, as they are not apt to break by sudden changes of heat. Small flasks of thin glass also; these are placed either over the naked fire, or in a vessel filled with sand, which is then called a *sand-bath.* This affords a more regular degree of heat, and renders the vessels less liable to be broken.

When the fluid which is evaporated must be preserved, then the operation is called distillation.

326. *Distillation* is evaporating in close vessels, when we wish to separate two fluids of different degrees of volatility, and to preserve the most volatile, or both of them.

The substance to be subjected to distillation is put into some vessel that will resist the action of heat, called a *retort,* an *alembic,* or a *still,* having a beak or neck projecting from it, to which is attached another vessel, to receive the fluid that rises first, which is called the *recipient,* or *receiver.* The vessel that contains the liquor to be distilled is placed upon the fire, or in a sand-bath, or over a lamp: the heat causes the most volatile fluid to rise in the form of vapour, and to pass into the receiver, where it is again condensed by cold. This condensation is sometimes assisted by making the vapour pass through a tube which is immersed in a vessel containing cold water.

327. *Decoction* is the same process as the last by boiling water.

The various degrees of heat which are required for the performance of chemical operations, from that of a wax-taper to that of the most powerful furnace, render a variety of fire-places, or furnaces, necessary for a chemist.

Those furnaces are either open at top, or they are covered with what is called a *dome,* and have a chimney, or tube, to carry off the heated air, smoke, &c. They are sometimes supplied with air from the natural action of the fire, which rarefies the air about the ignited fuel; and the rarefied air becoming specifically lighter, ascends into the chimney, whilst the colder, and consequently heavier air, is forced by the atmosphere to enter at the lower part of the furnace. Some furnaces are supplied with air by means of bellows; and those are applied for forging iron, or for reducing metals from the ore, which is called *smelting.* Hence the furnaces derive their various names, and are called *simple* or *open furnaces, reverberatory furnaces, wind,* or *air furnaces, blast furnaces, forges, smelting furnaces,* &c.

328. *Fusion.* The melting or causing any body to pass from the solid to the liquid state, by the action of fire, is called *fusion.* The fusion of metallic substances requires vessels sufficiently strong to resist the fire. Those vessels are mostly, if not always, made of earthen-ware, or porcelain, or a mixture of clay and powder of black-lead. They are called *crucibles,* and are sometimes vessels with covers made of earthen-ware; but sometimes the fused metal must be exposed to a current of air. In that case, the crucibles are broad and shallow. These are called cupels, and they are formed of calcined bones, mixed with a small quantity of clay, or of a mixture of clay and black-lead powder. But the cupels must not be placed in a closed furnace, or be surrounded by coals; for, in that case, the required current of air could not have access to the fused metal. They are therefore placed under a sort of oven of earthen-ware, which is called a *muffle,* which, with the included cupel, is exposed to the heat of a furnace.

CHAPTER XV.

MILITARY AND NAVAL TACTICS.

SECTION I.

FORTIFICATION.

329. THIS is a species of architecture, for in the construction of works of defence, we employ all the rules of that art agreeably to geometrical principles.

But the student must not expect here to find a treatise on each branch of the art. Confining ourselves to facts and terms, our observations will savour more of definitions than rules for practice.

Fortification is usually divided into ancient and modern; offensive and defensive; regular and irregular.

Ancient fortification consisted principally of defences constructed with trunks and branches of trees, mixed with earth, for security against the attacks of an enemy. Afterwards, when battering-rams, catapults, and other instruments of attack were invented, fortifications were constructed of thick walls of brick or stone, with towers, placed at suitable distances.

The object of *modern fortification* is to furnish defence against assailants with fire-arms, the walls are turned into ramparts, the towers into bastions, defended by numerous out-works; so constructed that they cannot be beaten down but by the fire of cannon. The works are contrived so, that one part flanks or defends another, and render the approach of the besiegers to any part very dangerous.

Regular fortifications are erected in the shape of regular polygons, the sides being at least a musket shot from each other, and fortified according to the rules of art.

Irregular fortifications, on the contrary, are those whose sides and angles are not uniform, owing to some irregularity of the ground. These usually occur in

Field fortification, or the constructing of temporary works for an army intrenched, or fortified in the field. In this position it covers a country, supplies the want of numbers, stops a superior enemy, or obliges him to engage at a disadvantage.

The materials used for field fortifications, are such as can be readily obtained, viz. sand-bags, earth, and fascines, or faggots of small wood, about ten feet long and one foot thick, fastened to the parapet, by pickets driven obliquely into the bank. When wood cannot be obtained for the fascines, the parapet is surmounted with turf, four inches thick, and a foot and a half square. But circumstances determine the dimensions of the work.

Bridges of boats are employed for accelerating the passage of troops across deep and rapid rivers. The most curious of this kind was

A Bridge of Boats built across the Hellespont.

330. Xerxes, king of Persia, commanded a bridge of boats to be laid over the Hellespont, for the passage of his forces from Asia into Europe. The sea which separates Sestos and Abydus, where the bridge was built, is seven furlongs over. The work was carried on with great expedition by the Phœnicians and Egyptians, who had no sooner finished it, but a violent storm arising, broke it in pieces, and dispersed or dashed against the shore the vessels of which it was composed: which when Xerxes heard, he fell into such a violent transport of anger, that he commanded three hundred stripes to be inflicted on the sea, and a pair of fetters to be thrown into it, injoining those who were trusted with the execution of his orders, to pronounce these words: "Thou salt and bitter element, thy master has condemned thee to this punishment, for offending him without a cause; and is resolved to pass over thee, in spite of thy billows, and insolent resistance." The extravagant folly and madness of this prince did not stop here; he commanded the heads of those who had the direction of the work to be struck off.

In their room he appointed more experienced architects to build two other bridges, one for the army, the other for the beasts of burden, and the baggage. When the whole work was compleated, and the vessels which formed the bridges secure against the violence of the winds, and the current of the water, Xerxes departed fom Sardis, where the army had wintered, and directed his march to Abydus. When he arrived at that city, he desired to see all his forces together; and, to that end, ascending a stately edifice of white stone, which the Abydenians had built, on purpose to receive him in a manner suitable to his greatness, he had a free prospect to the coast, seeing at one view both his fleet and land forces. The sea was covered with his ships, and the large plains of Abydus with his troops, quite down to the shore. While he was surveying the vast extent of his power, and deeming himself the most happy of mortals, his joy being all on a sudden turned into grief, he burst out into a flood of tears; which Artabanus perceiving, asked him, what had made him, in a few moments, pass from an excess of joy to so great a grief. The king replied, that, considering the shortness of human life, he could not restrain his tears; for, of all these numbers of men, not one, said he, will be alive an hundred years hence. All things being now in readiness, and a day appointed for the passing over of the army, as soon as the first rays of the sun began to appear, all sorts of perfumes were burnt upon the bridge, and the way strewed with myrtles. At the same time, Xerxes, pouring a libation into the sea, out of a golden cup, and addressing the Sun, implored the assistance of that Deity, begging that he might meet with no impediment so great as to hinder him from carrying his conquering arms to the utmost limits of Europe. This done he threw the cup into the Hellespont, with a golden bowl, and a Persian scymitar; and the foot and horse began to pass over that bridge which was next to the Euxine, while the carriages and beasts of burden passed over the other, which was placed nearer the Ægine sea. The bridges were boarded, and covered over with earth, having rails on each side, that the horses and cattle might not be frightened at the sight of the sea. The army spent seven days and nights in passing over, though they marched day and night, without intermission, and were, by frequent blows, obliged to quicken their pace. At the same time, the fleet made to the coasts of Europe. After the whole army was passed, Xerxes advanced with his land forces, through the Thracian Charsonesus to Doriscus, a city at the mouth of the river Hebrus, in Thrace: but the fleet steered a quite different course, standing to the westward for the promontory of Sarpedon, where they were commanded to attend farther orders. Xerxes, having encamped in the large plains of Doriscus, and judging them convenient for reviewing and numbering his troops, dispatched orders to his admirals to bring the fleet to the adjacent shore, that he might take an account both of his sea and land forces. His land army, upon the muster, was found to consist of one million seven hundred thousand foot, and fourscore thousand horse; which, together with twenty thousand men who conducted the camels, and took care of the baggage, amounted to one million eight hundred thousand men. His fleet consisted of twelve hundred and seven large ships, and three thousand gallies and transports: on board all these vessels, there were found to be five hundred and seventeen thousand six hundred and ten men. So that the whole number of sea and land forces, which Xerxes led out of Asia to invade Greece, amounted to two millions three hundred and seventeen thousand six hundred and ten men.

SECTION II.

TACTICS, DISCIPLINE, AND DISTINCTIONS OF RANK.

331. *Military tactics* teach the art of disposing forces in battle array, and performing its proper motions and evolutions.

The Greeks, skilful in this part of the military art, had public professors of it, called Tactici, who taught and instructed their youth. *Tactics* signifies also the art of inventing, and making machines for throwing darts, arrows, stones, fire-balls, &c. by means of slings, bows, and counterpoises. *Naval tactics*, instruct us in the arrangement of a fleet for an engagement by sea.

Military discipline, or the training of the soldiers, and the due enforcement of the laws and regulations instituted by authority, may be considered the soul of all armies; unless it be established with prudence, and supported with resolution, assemblies of armed men are little better than a rabble, and more dangerous to a state than its enemies.

By the force of discipline, men are kept in obedience to command, in opposition to the impulse of their passions; and make each army, as it were, a complicated, but immense and energetic machine.

Rank is the appointment of officers or a gradation of authority necessary towards the establishment of discipline and subordination.

An army is commanded by a *captain-general* or commander-in-chief, and general and staff-officers. *Field-marshals*, long disused in the British army, have been revived in the persons of their Royal Highnesses the duke of York, and the prince of Cobourg; the duke of Wellington, &c. The rank of commander-in-chief corresponds to the degree of field-marshal in the French service. A lieutenant, or even a major-general, has sometimes the appointment of commander-in-chief. When an army is considerable, the following is deemed an adequate staff, exclusive of the commander-in-chief: a general for the horse, and one for the foot, or general for each wing of the army: a major-general for every two brigades; and nearly half that number of lieutenant-generals. But the duties of all these are much the same; the terms denoting chiefly the gradations of rank.

General officers may command any number of men, from a company or troop to several regiments. Generals have no pay except when employed; but then they have from two to ten pounds a day.

The *commander-in-chief*, or *captain general*, or *general*, commands all the military of a nation or army; he receives himself his orders from the king, and communicates them to all general officers, who distribute them through all the corps of the army.

Colonels command regiments—but there are *lieutenant-colonels* who are the second officers in regiments, and command in the absence of the colonels.

The *Major-general* acts immediately under the general, receiving his orders and delivering them out to the majors of brigades, with whom he concerts what troops are for duty or guard, detachments, convoys, or foraging parties.

The *major of a regiment* conveys all orders to the regiment after he has drawn them up, sees it march, provides quarters, &c. He is the only officer of an infantry regiment who is allowed a horse in service, to facilitate communications. In a regiment of horse, the major commands in the colonel's absence.

A *brigadier* commands a brigade; and the eldest colonels are usually such as are advanced to this post. Whoever is upon duty is brigadier of the day. He marches at the head of his own brigade, and is allowed a serjeant and ten men of his own brigade for his guard. The rank of a brigadier-general in the British service used to be suppressed in time of peace. Brigadiers, or sub-brigadiers, are posts in the horse-guards. The brigadier or brigadier-general appoints an officer called a *Brigade Major* to assist him in the management of his brigade. Experienced captains are appointed to this post; and act in the brigade as major-generals do in the army, receiving their orders from their commanders.

Captains. A *captain-general* is he who commands in chief. A *captain* of a *troop*, or company, commands a troop of horse, or company of foot under a colonel. His duty is to be careful to keep his company full of able-bodied soldiers; to visit their tents or lodgings; to see what is wanting; to pay them well; and keep them neat and clean. He has the power, in his own company, of making serjeants and corporals. In the horse and foot-guards, the captains have the rank of colonels.

The commissioned officers subordinate to the captain, are the lieutenants and ensigns, commonly called subaltern officers. These, though their rank is not the same, perform duty together without distinction. Their ordinary duties are in garrison, guards, detachments, courts-martial, the visiting of hospitals and barracks, fatigues on working parties, and orderly duties. And no officer can exchange his duty with another, except by permission of the commanding officer. Thus, the ensign bears the colours and has charge of them in battle, yet is he under the lieutenant.

The *adjutant* assists the major, and receives his orders nightly from the brigade-major; these after being submitted to the colonel, he delivers to the serjeants. Almost all duties are regulated by the adjutant as major's assistant, as detachments, guards, the charge of ammunition, the prices of bread, beer, &c.

The *quarter-master* is rather a civil than a military officer; and though next to the adjutant, he has nothing to do with the discipline of the regiment. He superintends the clothing quarters, ammunition, firing, &c.

The *surgeon*, a commissioned officer on the staff of the regiment, requires to be skilled in physic, pharmacy, and anatomy.

The *chaplain*, the last commissioned officer on the staff, is generally allowed to act by deputy when he thinks proper.

Serjeant-major, the first, and properly speaking, the only non-commissioned officer on the staff, bears the same subordinate relation to the adjutant, as the adjutant does to the commanding officer; and as the adjutant keeps register of the officers, so does the serjeant-major of the sergeants and corporals, whom he warns in turn for duty, and orders the quota of men each company is to furnish. The serjeant-major attends all parades, to see if the exact number of men are there, and that they are clean and well dressed. He is to make the other serjeants and corporals responsible for neglect in any of those particulars. When the rolls are called, he assembles the serjeants of each company in front or rear of the regiment, in order to receive their reports, and deliver them to the adjutant. He must be well acquainted with the exercise and manoeuvres, in which it is frequently his business to instruct the young officers. He must be versed in regimental duty in general, and his own in particular.

The non-commissioned officers are the *serjeants* and *corporals*, and upon a proper choice of these, the discipline of the company principally depends; it is more immediately their business to form the soldiers: from their continual intercourse with the men, they have it in their power to attend to matters which cannot come under the notice of others. The serjeants being the nerves and sinews of a corps, a commanding officer in promoting private soldiers to the knot, has principally in view the forming of proper characters for the halbert. A serjeant's command is from twelve to eighteen, with a corporal, and that of a corporal, from three to nine privates. The non-commissioned officer cannot change his duty without leave of the serjeant-major, or the adjutant, as well as the commanding-officer of his company. When under arms, or drawn up in rank, the corporals are not to assume any command, or give directions, but must attend to the word of command like the private men. They should be expert and graceful in handling their arms, as they are to serve for models to the young soldiers.

The *drum-major* commands the *drum boys*, for whose good appearance he is answerable, and he looks to their drums that they be in good order. He has many other trifling duties to perform, which it would be tedious to narrate.

The *soldier*, though humble in rank, is mighty in the collective force of an army.

SECTION III.

CORPS OF AN ARMY.

332. A battalion has from five to eight hundred men, but in war time one thousand. These are again divided into companies. In garrison the oldest regiments on parade take the right, those second on the left, and the youngest fall into the centre.

Each battalion consists of four divisions; each division of four platoons.

A *brigade* consists of several regiments, either foot or horse, under the command of a brigadier.

An army is divided into brigades of horse, and brigades of foot. A brigade of a troop of guards is a third part, but if the troop consist of one hundred, then only a sixth. There are, properly speaking, three sorts of brigades, viz. the brigade of an army, the brigade of a troop of horse, and the brigade of artillery. A brigade of the army is either infantry or cavalry, whose exact number is not fixed, but generally consists of three regiments, or six battalions; a brigade of horse may consist of eight, ten, or twelve squadrons; and that of artillery, of eight or ten pieces of cannon, with their appurtenances, and the complement of men.

Cavalry are soldiers mounted on horseback. The chief use of cavalry is to make frequent excursions to disturb the enemy, and ensure the retreat of the infantry.

Dragoons are employed both on foot and on horseback. They are usually posted in the front of the camp, and if the ground permit, march first to the charge. They are divided into brigades like the cavalry, and each regiment into troops; each troop having a captain, lieutenant, cornet, quarter-master, two serjeants, three corporals, and two drums. Dragoons are useful where dispatch is requisite.

Hussars, a soldiery in Poland, and Hungary, commonly opposed to the Ottoman cavalry, are horsemen cloathed in tyger's and other skins, and decorated with plumes of feathers; their arms are the sabre and bayonet. The German and British Hussars are generally handsome men, well mounted, but most fantastically and expensively cloathed; but the trappings of a tailor's board are more likely to beget pusillanimity than courage. However, they are very resolute, and better in skirmishes than in a set battle.

Lancers are cavalry furnished with a lance, sabre, and pistol, and well mounted on light but hardy horses. These troops serve well in skirmishes and excursive duties.

Light horse are cavalry of lighter make and equipment than the heavy dragoons or life guards. And we sometimes say of a single independent troop, the *light horse*.

A *squadron* amounts to about two hundred horse, or more properly, three troops of fifty men each; and a troop is a small body of men from fifty to eighty, commanded by a captain. There are usually ten troops in a regiment.

A *regiment* consists of several companies of infantry, or troops of horse, commanded by a colonel and major. The number of men in a regiment is from six hundred to one thousand.

Company is a body of infantry, commanded by a captain. There are commonly fifty privates, three serjeants, three corporals, and two drums. A company in the guards consists of eighty private men. *Independent companies* are not embodied into regiments.

Fusileers are foot soldiers armed with muskets, which are generally slung, and there is a regiment of fusileers to guard the artillery.

Militia are troops raised at the expense of the counties, but equipped, paid, and trained by the government. Being selected by ballot in their respective counties for local defence, they are never moved from England to Ireland, or Scotland to England, unless the Act of Parliament for their enrollment specifies such movement to take place. Wounded militia-men enjoy the same privileges as men of the regular army.

Grenadiers form one company of every regiment. They are the tallest men, picked out of the whole, and march at the head of that regiment.

Janissaries, an order of infantry in the Turkish armies, and considered the foot guards of the grand signior. The discipline of these soldiers is in many respects analogous to that practised in the Roman legions.

Great Britain had in the late wars 30,000 cavalry, 150,000 infantry, and 5000 engineers and artillery-men, whose duty it was to direct fortifications, and to manage cannon in the field.

She had, besides, 80,000 militia and fensibles, who served for a limited period, and did not go abroad; 20,000 marines, soldiers who served on board of ship; and 10,000 local volunteers.

An army is divided into divisions, these again into brigades; and these last into regiments, consisting of 700 cavalry, or 1000 infantry; and each regiment is again subdivided into ten companies. Some regiments consist of two or three battalions; but each battalion generally consists of as many men as whole regiments of one battalion.

SECTION IV.

OF ARTILLERY AND MUNITIONS OF WAR.

333. THE word artillery denotes fire-arms, as

cannon mounted on carriages, and ready for use in the field, with balls, bombs, grenades, &c. The term, in a more extensive meaning, includes the powder, the matches, instruments for fire-works, the utensils of ordnance, the machines which facilitate their motion, the vehicles over which they traverse rivers, and, in short, all that enters into the form of a train of artillery. Artillery, in a particular sense, signifies the science of artillery or gunnery, comprehending geometry, trigonometry, conic sections, mechanics, fluxions, motions of projectiles, whether in a non-resisting, or a resisting medium; the nature constitution, and expansive force of gunpowder, &c.

The changes introduced into the art of war, by the invention of gunpowder, were very slow. The martial adventurers of older times were not fond of relinquishing the arms to which they had been accustomed; and it was difficult to find instruments to manage and direct an agent so impetuous as gunpowder. Some of their cannons were exceedingly large, and others very small. Some discharged balls of five-hundred pounds weight, and required fifty horses to draw them, and others were not much heavier than a musquet. Many of the cannon-balls were made of stone. In 1419, Henry V. gave a commission to John South, clerk of the ordnance, and John Bennet, mason in Maidstone to press a sufficient number of masons to make seven thousand cannon-balls, in the quarries of Maidstone-heath. It is a curious and well-attested fact, that the art of discharging red-hot balls from cannons was known and practised early in this period. When an English army, commanded by the duke of Gloucester, besieged Cherbourg, in 1418, the besieged discharged red-hot balls of iron from their cannon into the English camp, to burn the huts in which the soldiers were lodged.

Though great guns were now used both in the attack and defence of places, no alterations were yet made in constructing and fortifying such places: the prodigious thickness and solidity of the walls of the Anglo-Norman castles, made them appear sufficiently strong to resist any force with which they could be assaulted. The truth is, that the people of England, in this period, were much more employed in beating down, than in building. Many large, strong, and magnificent castles were demolished or dismantled during the desolating civil wars, between the houses of York and Lancaster; while very few were erected; for when these castles were destroyed, their noble proprietors, who might have rebuilt them, were either killed or ruined.

It is only a few years since that the use of cannon or artillery, in the field, has become so general.

About the year 1548, the English Artillery consisted only of a master of artillery, lieutenant, surveyor, clerk, yeoman, master-gunner, gunstock-maker, two gun-founders, a gunsmith, artificer, master carpenter, and one hundred and nine gunners; the total charge for one year being 1547*l.* 9*s.* 2*d.* During the reign of Elizabeth, the establishment was increased, so that the salaries of the officers only amounted to 2074*l.* 10*s.* in the year 1597. From that period the augmentation was gradual till the American war, and the French revolution occasioned a very rapid increase. That æra of the French revolution may be considered that of its complete adoption; this was not a little aided by Dr. Anderson's invention of the *flying artillery*, which was submitted to, and rejected by, the English government during the American war, when the ingenious inventor carried his plan to France, where it was instantly adopted.

The present establishment of artillery consists of ten battalions, besides an invalided battalion. The works for guns and gun-carriages, &c. are carried on at the Royal Arsenal Woolwich, and are wonderfully extensive, employing usually four or five thousand men. The establishments at the Tower of London, and at Chatham, connected with the artillery, and ordnance, are also immense; and the expense to government very considerable, the ordnance estimates being now from four to five millions sterling annually.

334. *Engineers* draw out the plans of attack at sieges and for the defence of towns when besieged. They have the sole construction and disposition of all forts, redoubts, batteries, mines, &c. the fortifying of camps and ports, reconnoitering the enemy's works, sketching plans and surveys of a country, discovering advantageous methods for marching, retreating, attacking or defending. And they are usually men of good mathematical science, and well skilled in military architecture.

Obs. The royal military academy at Woolwich, established by Geo. II. in 1741, is a regular engineer college, where *cadets* are instructed in all those branches of literature and science which may fit them for commanding, artillerymen, engineers, and directing the operations of military architecture in the field.

335. *Cannon* are destructive instruments that were first used at the battle of Cressy in 1346, by Edward the Black Prince. At this battle, the French, whose number exceeded one hundred thousand, were defeated by thirty thousand English, chiefly by the valour of the prince of Wales, commonly called the *Black Prince,* from the dark hue of his armour.

Obs. Above thirty-five thousand of the French were slain, among whom were many of the principal nobility, twelve hundred knights, and fourteen hundred gentlemen; while the English lost only three knights, one esquire, and a small number of private men. On his return to the camp, Edward flew into the arms of the prince of Wales, who had distinguished himself in a remarkable manner. "My brave son!" cried he, "persevere in your honourable course. You are my son! for valiantly have you acquitted yourself to-day. You have shewn yourself worthy of empire."

336. A *Mortar* is a short piece of ordnance, thick and wide, for throwing bombs, carcasses, shells, and stones. English mortars are fixed at an elevation of forty-five degrees, as you see one in the area of the horse-guards; but ours is the only nation that so fixes them.

The use of mortars is reckoned older than that of cannon: for they were employed in the wars of Italy to throw balls of red hot iron, and stones, long before the invention of shells. The Germans are generally believed to be the first inventors; and it is affirmed that they first used them at the siege of Naples in 1435. Shells were certainly thrown out of mortars in 1588, at the siege of Wachtendorch in Guelderland, by the Earl of Mansfield. Shells were invented by an unfortunate accident. A citizen of Venlo, on a festival, celebrated in honour of the Duke of Cleve, threw some shells, one of which fell on a house, and set fire to it. By this misfortune the greatest part of the city was reduced to ashes, but an invention was made. Malter, an English engineer, in 1634, first taught the French the art of throwing shells. Red hot balls were thrown from mortars, at the siege of Stralsund in 1675; and since that time they have frequently been employed.

337. *Ordnance,* a general term for all sorts of

great-guns, cannon, and mortars, is, however, distinguished into two kinds, field-pieces, and cannon; the former are usually from four to twelve pounders; the latter from culverins to great guns, eight and forty pounders.

338. *Shot* is a general term for all sorts of balls, or bullets for fire arms, from a pistol to a cannon. Musket and pistol bullets are of lead; cannon-balls of cast metal.

339. *Bullet.* Chain bullets consist of two balls, joined by a chain three or four feet apart.

Two headed bullets are two halves of a bullet, joined by a bar or chain, chiefly used for cutting cords, cables, sails, &c. called also *chain* shot. *Branch* bullets, are two balls joined by a bar of iron five or six inches apart. *Hollow* bullets are shells cylindrical, with a fusee at one end. *Red hot* bullets are made so by being heated in a forge, in order to set fire to places where combustible matters are found.

340. A *Bomb* is a hollow iron ball or shell, thrown out of a mortar. Bombs are of different magnitudes, and are filled with gunpowder.

When shot from the mortar, a fusee in them takes fire, and its length is so adjusted, that by the time the shell has finished its flight, the fusee has burnt up, and explodes the gunpowder within so as to burst the shell to pieces just as it is falling to the ground; this, of course, increases its execution, and causes greater devastation.

341. A *grenade* resembles a bomb, but is less and may be cast with the hand. The usual weight of a grenade is three pounds; and filled with a strong powder lighted by a fusee.

342. *Gunpowder* we have elsewhere described.

343. *Muskets* were first used by the Spaniards about 1500; but they were very clumsy, being supported by a rest from the ground, and fired by a match.

Locks of flint and steel, called firelocks, were not introduced till the wars of William III. and Queen Anne.

The length of the musket is fixed to three feet eight inches, from the muzzle to the touch-pan, and its bore is such as may receive a ball of sixteen to the pound. There are two sorts of firing with muskets offensive and defensive. 1. *Offensive.* The object of fire against cavalry is to keep them at a distance, and to deter them from the attack. But against infantry, it cannot be too heavy or quick, and should be continued till the enemy is beaten or repulsed. 2. *Defensive* fire belongs principally to infantry, when posted on heights, which are to be defended by musketry. As soldiers generally present too high, and as fire is the greatest consequence to troops that are on the defensive, the habitual mode of firing should therefore be rather at a low level than a high one.

344. *Carbines* are used by dragoons slung at a belt over the right shoulder. But those troops called carbineers, are light horse with carbines about two feet long in the barrel.

345. A *pistol* is used with one hand, and kept in a *holster* by dragoons, &c.

346. A *bayonet* is of great use to the dragoons and fusileers, after they have spent their powder and ball.

The French used to be much celebrated for their charge with the bayonet. But the muscular strength and determined resolution of the British has, of late, diminished this celebrity: for it is not to be concealed that no troops can withstand the British when the battle is decided by the bayonet.

347. A *halbert* is a staff about five feet long, with a steel head, like a crescent. This was anciently a common weapon, and is still carried by the serjeants of foot. It was called the Danish axe, because first borne by the Danes; from whom it passed to the Scots; thence to the English, and afterwards to the French.

348. A *poinard*, used chiefly by foreign and Asiatic nations, is a short sword.

349. *Archery* anciently one of the principal modes of warfare, was much encouraged even in England. Now it is confined to Asiatic and American tribes, or roving Indians. Henry V. of England, sailed for Harfleur with about 24,000 foot, mostly archers.

350. The *bow* is the most ancient of all weapons.

A Lapland bow is made of two pieces of tough and strong wood, shaved down to the same size, and then flatted on each side; the two flat sides of the pieces are brought closely and evenly together, and then joined by means of a very strong glue. The two pieces united, in this manner, will seldom separate; and the bow expels the arrow with greater force. Among the ancients, bow-strings were made of horse-hair; though Homer's bow strings were made of hides cut into small thongs. The bows were composed of wood, and some of horn. The Scythian bows were distinguished from those of other nations by their incurvation, which formed a half-moon or semi-circle. A *cross-bow* consists of a steel bow, set in a shaft of wood, and furnished with a string and a trigger. It serves to throw bullets, large arrows, darts, &c. The ancients had machines for throwing many arrows at once.

SECTION V.

NAVY.

351. It would be folly to depart from the navy of Great Britain for illustration of this section. No nation in ancient or modern times boasted a navy equal to ours during the last war.

Of the arts and professions which attract notice, none is more astonishing and marvellous than navigation, in its present state, comparing the small craft of antiquity to a majestic first-rate, containg 1000 men, with their provisions, drink, furniture, apparel, and other necessaries for many months, besides 100 pieces of heavy ordnance, and bearing all this vast apparatus safely to the most distant shores. How great is the disparity? 8000lb. of provisions are required daily, in such a ship. Suppose her fitted out for three months, we shall find her laden with 720,000lb. of provisions. A cannon if called a forty-two pounder weighs about 6,100lb, if made of brass; and about 5,500lb. if made of iron; there are twenty-eight or thirty of these on board a ship of 100 guns; their weight, exclusive of their carriages, amounts to 183,000lb.

On the second deck, thirty twenty-four pounders; each weighing about 5,100lb., and therefore altogether, 153,000lb.; and the weight of twenty-eight twelve-pounders on the lower deck, amounts to about 75,400lb.; fourteen six-pounders on the upper deck, to 26,000lb.; and on the round-tops, there are three-pounders and swivels of smaller size. The complete charge of a forty-two-pounder weighs about 64lb., and upwards of 100 charges are required for each gun. All this amounts nearly to the same weight as the guns themselves. Every ship must be provided against exigencies, with two sets of sails, cables, cordage, and tacklings: the stores, likewise, consisting of planks, pitch, and tow: the small arms, bayonets, swords, and pistols, make no inconsiderable load; to which we must finally add, the weight of the crew; so that one of these large ships carries at least 2000 tons burden, and at the same time, is steered and governed with as much ease as the smallest skiff on the Thames.

352. The British naval force on the 1st of January 1813, was as follows:—at sea 79 ships of the line; nine from 50 to 44 guns; 122 frigates; 77 sloops and yachts; four bombs, &c.; 161 brigs; 54 cutters; 52 schooners, &c. In port and fitting, 39 of the line; 11 from 50 to 44 guns; 29 frigates, hospital-ships, prison-ships, &c. 28 of the line; two from 50 44; two frigates; one yacht. Ordinary and repairing for service, 77 of the line; 10 from 50 to 44 guns; 70 frigates; 37 sloops; 8 bombs, 11 brigs; 1 cutter; 2 schooners. Building, 29 of the line; four from 50 to 44 guns; 15 frigates; 5 sloops, &c. 3 brigs.

A fleet of ships of war is generally divided into three divisions; and commanded by Admirals, Vice-admirals, or Rear-admirals, of the white, blue, and red flags.

A Squadron of ships is a division or part of a fleet commanded by a commodore, or by a rear or vice-admiral. The number that forms a squadron is not fixed, for a small number in a body and under one commander may make a squadron. If the ships are numerous, they are sometimes divided into three squadrons, and each squadron may be again divided into three divisions.

A Frigate is a light-built fast sailing ship, having commonly two decks, whence that called a light frigate is a frigate with only one deck. These vessels mount from 20 to 44 guns, and make excellent cruizers.

Hulks are old ships cut down to the gun-deck, and fitted with a large wheel for careening. Their gun-decks are from 113 to 150 feet long, and from thirty to forty feet broad; they will carry from 400 to 500 tons. Hulks are also employed at Woolwich, Portsmouth, Sheerness, &c. to receive convicts under sentence of transportation; the vessels are moored at such a distance from shore, as precludes the possibility of the men's escape; and the convicts are taken daily on shore to work, under a strong guard, at pile-driving, harbour cleansing, and other employments in the several public departments.

A Hoy is a small vessel or bark, whose yards are not across, nor the sails square, like those of ships, but the sails like a mizen, so that she can sail nearer the wind, than a vessel with cross sails can do.

Sloops are appendages to men of war, about 60 tons burthen, and carrying 30 men. They are light vessels, with only a small main-mast, fore-mast, and lug-sails to haul up and let down, on occasion, and are commonly fast sailers.

Smacks are small vessels with one mast; they sometimes are employed as tenders on a man of war: they are also used for fishing upon the coasts.

Store ships are generally brigs of from 300 to 600 tons: they carry ordnance, and military stores, to the out-ports, or to an army when abroad.

A Yacht, a vessel for the conveyance of passengers, is also sometimes adorned for regal use. It is furnished with masts and sails, has one deck, carrying from four to twelve guns, with from twenty to forty men; burthen from thirty to 160 tons. They are used for running and making pleasure excursions.

A Galley is a low-built Mediterranean vessel, having oars and sails. Gallies have usually twenty-five or thirty benches of oars on each side, and four or five galley-slaves on each bench. The galley usually carries a large gun, two bastard pieces, and two small pieces. It is from twenty to twenty-two fathoms long, three broad, and one deep, and has two masts, viz. a main-mast and a fore-mast, which may be struck or lowered at pleasure.

Galley of Hiero, King of Syracuse.

353. This galley was looked upon as one of the greatest wonders of the age in which Hiero lived. Archimedes, who was overseer of the work, spent a whole year in finishing it, Hiero daily animating

the workmen with his presence. This ship had twenty benches of oars, three spacious apartments, and all the conveniences of a large palace. The floors of the middle apartment were all inlaid, and represented in various colours the stories of Homer's Iliad. The ceilings, windows, and all other parts, were finished with wonderful art, and embellished with all kinds of ornaments. In the uppermost apartment there was a spacious gymnasium, or place of exercise, and walks, with gardens and plants of all kinds, disposed in wonderful order. Pipes, some of hardened clay, and others of lead, conveyed water all around to refresh them.

But the finest apartment was that of Venus, the floors being inlaid with agates, and other precious stones, the inside lined with cypress wood, the windows adorned with ivory, paintings, and small statues. In this apartment there was a library, and a bath with three great coppers, and a bathing vessel made of one single stone of various colours, and containing two hundred and fifty quarts. It was supplied with water from a great reservoir at the head of the ship, which held an hundred thousand quarts. The vessel was adorned on all sides with fine paintings, and had eight towers of equal dimensions, two at the head, two at the stern, and four in the middle. Round these towers were parapets, whence stones might be discharged against the enemy's vessels when they approached. Each tower was constantly guarded by four young men completely armed, and two archers. To the side of the vessel was fastened an engine made by Archimedes, which threw a stone of three hundred weight, and an arrow of eighteen feet, the distance of a stadium, or an hundred and twenty-five feet. Though the hold of this vessel was exceeding deep, a single man could soon clear it of water with a machine invented for that purpose by Archimedes. An Athenian poet having composed some verses on this magnificent vessel, Hiero, who understood the value of verse, rewarded him with a thousand medimni, that is, six thousand bushels of wheat, which he caused to be carried to the Pyreæus, or port of Athens. Hiero afterwards made a present of this great vessel to Ptolemy, king of Egypt, and sent it to Alexandria.

Plunging Boats and Torpedoes.

354. In December, 1797, Mr. Fulton made an experiment, in company with Mr. Barlow, on the Seine, with a machine which he had constructed, and by which he designed to impart to carcases of gunpowder a progressive motion under water, to a given point, and there to explode them. But he was disappointed in the performance of this machine.

A want of funds to enable him to carry his design into execution, induced him to apply to the French directory. They at first gave him great reason to expect their countenance and encouragement; but after a long and irksome attendance at the public offices, to his great surprise and disappointment, he received a note from the minister of war, informing him that the directory had totally rejected his plan.

Not yet discouraged, he offered his project to the Dutch government, through Mr. Schemelpeninck, who was then at Paris as ambassador from Holland. A commissioner was in consequence appointed by the executive directory of the Batavian republic, to examine his models; but he met with another disappointment. The commissioners spoke so lukewarmly of his propositions, that the Dutch government would not give him sufficient encouragement.

But the French government changed. Bonaparte placed himself at the head of it, with the title of First Consul.

Mr. Fulton soon presented an address to him, soliciting him to patronise the project for submarine navigation, and praying him to appoint a commission, with sufficient funds and powers to give the necessary assistance. This request was immediately granted, and Messieures Volney, La Place, and Monge were named the commissioners.

In the spring of the year 1801, Mr. Fulton repaired to Brest, to make experiments with the plunging boat he had constructed the preceding winter. This, as he says, had many imperfections, natural to a first machine of such complicated combinations. Added to this, it had suffered much injury from rust, in consequence of his having been obliged to use iron instead of brass or copper, for bolts and arbours.

On the third of July, 1801, he embarked with three companions on board his plunging boat in the harbour of Brest, and descended in it to the depth of five, ten, fifteen, and twenty-five feet; but he did not attempt to go lower, because he found that his imperfect machine would not bear the pressure of a greater depth. He remained below the surface one hour. During this time they were in utter darkness. Afterwards he descended with candles; but, finding a great disadvantage from their consumption of vital air, he caused, previously to his next experiment, a small window of thick glass to be made near the bow of his boat, and he again descended with her on the 24th of July, 1801. He found that he received from his window, or rather aperture covered with glass, (for it was no more than an inch and a half in diameter,) sufficient light to enable him to count the minutes on his watch. Having satisfied himself that he could have sufficient light when under water; that he could do without a supply of fresh air for a considerable time; that he could descend to any depth, and rise to the surface with facility; his next object was to try her movements, as well on the surface as beneath it. On the 26th of July, he weighed his anchor and hoisted his sails: his boat had one mast, a mainsail, and jib. There was only a light breeze, and therefore she did not move on the surface at more than the rate of two miles an hour; but it was found that she would tack and steer, and sail on a wind or before it, as well as any common sailing boat. He then struck her masts and sails, to do which, and perfectly to prepare the boat for plunging, required about two minutes. Having plunged to a certain depth, he placed two men at the engine, which was intended to give her progressive motion, and one at the helm, while he, with a barometer before him, governed the machine, which kept her balanced between the upper and lower waters. He found that, with the exertion of one hand only, he could keep her at any depth he pleased. The propelling engine was then put in motion, and he found upon coming to the surface, that he had, in about seven minutes, made a progress of four hundred meters, or about five hundred yards. He then again plunged, turned her round while under water, and returned to near the place he began to move from. He repeated his experiments several days successively, until he became familiar with the operation of the machinery, and the movements of the boat. He found that she was as obedient to her helm under water, as any boat could be on the surface; and that the magnetic needle traversed as well in the one situation as the other.

On the 7th of August, Mr. Fulton again descended with a store of atmospheric air compressed into a copper globe, of a cubic foot capacity. Thus prepared, he descended with three companions to the depth of about five feet. At the expiration of an hour and forty minutes, he began to take small supplies of pure air from his reservoir, and did so as he found occasion, for four hours and twenty minutes. At the expiration of this time he came to the surface, without having experienced any inconvenience from having been so long under water.

Mr. Fulton was highly satisfied with the success of these experiments; it determined him to attempt to try the effects of these inventions on the English ships, which were then blockading the coast of France, and were daily near the harbour of Brest.

His boat at this time he called the submarine boat, or the plunging boat; he afterwards gave it the name of the Nautilus: connected with this machine, were what he then called submarine bombs, to which he has since given the name of Torpedoes. This invention preceded the Nautilus. It was, indeed, his desire of discovering the means of applying his torpedoes, that turned his thoughts to a submarine boat. Satisfied with the performance of his boat, his next object was to make some experiments with the torpedoes. A small shallop was anchored in the roads, with a bomb containing about twenty pounds of powder; he approached to within about two hundred yards of the anchored vessel, struck her with the torpedo and blew her into atoms. A column of water and fragments was blown from eighty to one hundred feet in the air. This experiment was made in the presence of the prefect of the department, Admiral Villaret, and a multitude of spectators.

St. Aubin, a member of the tribunate, gives in the Journal of Commerce of the 20th of January, 1802, an account of a submarine boat, which he says Mr. Fulton was then constructing. In this, however, there is a mistake. Mr. Fulton had projected another boat of this description, upon a larger and an improved plan; but he had not the means of executing it, and all his experiments were made with the small boat he first constructed, and which, as we have before remarked, he found at the end of the winter much impaired by the rusting of some parts of the machinery. St. Aubin's account is as follows: "The diving boat, in the construction of which he is now employed, will be capacious enough to contain eight men, and provisions enough for twenty days, and will be of sufficient strength and power to enable him to plunge one hundred feet under water, if necessary. He has contrived a reservoir of air, which will enable eight men to remain under water eight hours. When the boat is above water, it has two sails, and looks just like a common boat; when she is to dive, the mast and sails are struck.

In making his experiments, Mr. Fulton not only remained a whole hour under water with three of his companions, but had the boat parallel to the horizon at any given distance. He proved that the compass points as correctly under water as on the surface, and that, while under water, the boat made way at the rate of half a league an hour, by means contrived for that purpose.

Through the summer of 1801, and till the project was relinquished on account of the season, Mr. Fulton appears to have been watching the English ships which were on the coast; but though some of them daily approached off the harbour, yet none came so near, or anchored in such a situation, as to be exposed to the effects of his attempts. In one instance, he came very near a British seventy-four; but she just in time made such a change of position as to save herself.

The English were not without some information as to these extraordinary attempts which their enemies were making; and, however the French may have thought of Mr. Fulton's projects, they certainly occasioned some uneasiness in England. Lord Stanhope spoke of them with great anxiety in the house of Lords. In 1803, he formed an association of gentlemen, for the purpose of procuring information as to the progress of Mr. Fulton's designs, and what might be their consequences. This association made a report to the then British minister, Lord Sidmouth, and this led to a communication from him to Mr. Fulton; the object of which was to deprive France of the benefit of his inventions and services, and give England the advantage of them, by inducing him to withdraw from France.

In a paper which Mr. Fulton read to certain gentlemen, who were appointed by the British ministry in the month of August, 1806, to confer with him, he says, "at all events, whatever may be your award, I never will consent to let these inventions lie dormant should my country at any time have need of them. Were you to grant me an annuity of twenty thousand pounds a year, I would sacrifice all to the safety and independence of my country."

Some time after his return to Paris, the agent whom he was to have met at Amsterdam, made his appearance in the French metropolis, bearing a letter from Lord Hawkesbury to Mr. Fulton, which induced him to proceed to London, where he arrived in May, 1804. Lord Sidmouth was then out of office, and Mr. Pitt had resumed the administration. The new ministry seemed to approve of what had been done by their predecessors, in relation to Mr. Fulton. He soon had an interview with Mr. Pitt and Lord Melville. When Mr. Pitt first saw a drawing of a torpedo, with a sketch of the mode of applying it, and understood what would be the effects of its explosion, he said, that if introduced into practice, it could not fail to annihilate all military marines.

It would have been extraordinary if Mr. Pitt, entertaining this opinion, should, as the minister of a nation which had then the only navy in the world, have felt cordially disposed to encourage an invention, that might deprive her of the mighty superiority she derived from her fleets. This was certainly the view that some of her statesmen had of the subject. When Mr. Fulton had an interview with the Earl St. Vincent, exhibited to him a torpedo, and described the effects it had produced, the noble earl, in the strong language of his professsion, rather than in a style comporting with his new dignity, exclaimed against Mr Pitt for encouraging a mode of warfare, which he said, with great reason, they who commanded the seas did not want, and which, if successful, would wrest the trident from those who then claimed to bear it as the sceptre of supremacy on the ocean.

In June, the British ministry appointed a commission to examine Mr. Fulton's projects. The commissioners were Sir Joseph Banks, Mr. Cavendish, Sir Home Popham, Major Congreve, and Mr. John Rennie. Many weeks passed before Mr. Fulton could prevail on them to do any thing, and finalty, when they met, they reported against the submarine boat as being impracticable. In a letter to the ministry, Mr. Fulton complains that this report was made without his having been called upon for any explanations, and although the gentlemen who made it had before them no account of what had been done. Indeed, in the first interview which Mr. Fulton had with Mr. Pitt and Lord Melville, the latter condemned the Nautilus without a moment's consideration.

About this time, an expedition was fitted out against the French flotilla in the roads of Boulogne. In the night, torpedoes were thrown, by boats from a British squadron, across the bows of two of the French gun-brigs. The Frenchmen, when they discovered the torpedo-boats, exclaimed, with horror, that the infernal machines were coming! They had in their minds, no doubt the effects of some vague reports as to Mr. Fulton's engines; and were terrified by knowing what had been the tremendous consequences of the explosion, in the streets of Paris a short time previously, of a machine intended against the life of Bonaparte.

The torpedoes exploded alongside of the French vessels, without doing them any injury. Mr. Fulton imputed this failure to a mistake, arising from want of experience, in what was apparently a slight matter. The torpedo had been so placed, as that it hung perpendicularly by the side of the vessel, whereas it should have been so arranged, as that the current would have swept it under her bottom. This he was convinced, might be accomplished by the simple contrivance of attaching to the torpedo a bridle, in such a manner as that it should lie in the water, at an angle with the line of direction of the current. This, when the torpedo was stopped by a line connected with it, meeting the hawser or bow of the vessel, would give it a sheer which would carry it towards the keel of the vessel to be destroyed. Mr. Fulton's subsequent experiments, proved that his theory on this subject was perfectly correct,

On the fifteenth of October, 1805, he blew up a strong built Danish brig, of the burden of 200 tons, which had been provided for the experiment, and which was anchored in Walmer roads, near Deal, within a mile of Walmer Castle, the then residence of Mr. Pitt. He has given an interesting account of this experiment in a pamphlet which he published in this country, under the title of Torpedo War. In a letter to Lord Castlereagh, of the 16th of October, 1805, he says " yesterday, about four o'clock, I made the intended experiment on the brig, with a carcass of 170 pounds of powder; and I have the pleasure to inform you, that it succeeded beyond my most sanguine expectations. Exactly in fifteen minutes from the time of drawing the peg, and throwing the carcass into the water, the explosion took place. It lifted the brig almost bodily, and broke her completely in two. The ends sunk immediately, and in one minute nothing was to be seen of her but floating fragments; her main-mast and pumps were thrown into the sea; her fore-mast was broken in three pieces; her beams and knees were thrown from her decks and sides, and her deck planks were rent to fibres. In fact her annihilation was complete, and the effect was most extraordinary. The power, as I had calculated, passed in a right line through her body, that being the line of least resistance, and carried all before it. At the time of her going up, she did not appear to make more resistance than a bag of feathers, and went to pieces like a shattered egg-shell."

Notwithstanding the complete success of this experiment, the British ministry seem to have been but little disposed to have any thing further to do with Mr. Fulton or his projects. Indeed the evidence it afforded of their efficacy, may have been a reason for this. However Mr. Pitt and Lord Melville may have thought on the subject, there had been a change in the administration, and the new ministers may have agreed with the Earl St. Vincent, that it was great folly in them to encourage a project, which, if it succeeded, would destroy the maritime power of Great Britain. Lord Grenville and his cabinet were not only indisposed to encourage Mr. Fulton; but they were unwilling to fulfil the engagements which their predecessors had made; and Mr. Fulton, after some further experiments, of which we have no account, wearied with incessant applications, disappointments, and neglect, at length embarked for his native country.

So far from being discouraged by the failure of his torpedoes to produce the desired effect in the attempts which had been made in Europe, to apply them as instruments of hostility, he felt not the least diminution of his confidence, because he saw, as he said, that these failures were to be attributed to trivial errors, which actual experience only could discover, and which were easily to be corrected. He had not been landed in America a month, before he went to the seat of government, to propose to the administration to enable him to prosecute a set of experiments with his torpedoes. He found Mr. Madison, then Secretary of State, and the Secretary of the Navy, Mr. Smith, much disposed to encourage his attempts, the success of which Mr. Fulton, by his ingenious models and drawings, with his lucid and engaging mode of lecturing upon them, made to appear so probable. The government authorized a certain expenditure to be made, under the direction of Mr. Fulton, for this purpose.

On the 20th of July, 1807, in pursuance of the experiments which the government had authorized him to make, Mr. Fulton blew up, with a torpedo, in the harbour of New York, a large hulk brig, which had been provided for the purpose.

The members of Congress were so favourably impressed with respect to Mr. Fulton's inventions, by the lectures which he had given upon them in their presence, that, in March, 1810, they passed an act, making an appropriation for trying practically the use of torpedoes, and submarine explosions. For this purpose, five thousand dollars were granted, to be expended at the discretion of the president, under the immediate direction of the secretary of the navy.

Chancellor Livingston, after a long examination of each particular subject which the experiments had presented, expresses himself as follows: "Upon the whole, I view this application of powder as one of the most important military discoveries which some centuries have produced. It appears to me to be capable of effecting the absolute security of our ports, against naval aggression; provided, that, in conjunction with it, the usual means necessary to occupy the attention of the enemy, are not neglected."

SECTION VI.

NAVAL DISTINCTIONS IN RANK.

355. The Lord High Admiral of England is an officer of great trust, the king is nominally Lord High Admiral, while the duties of the office are executed by commission, called the Board of Admiralty, consisting of five commissioners, denominated Lords of the Admiralty, one of whom, as resident, is called first Lord.

The Board of Admiralty takes cognizance of every thing transacted at sea, the management of all maritime affairs, the direction of the Navy, and both civil and criminal offences committed on the high seas. Under this court is also a court-merchant, or court of equity, where all differences between merchants are decided according to the rules of the civil law. This court is held three or four times a year at the Old Bailey, and one of the judges generally acts as the Lord Admiral's deputy.

356. An Admiral is a great officer, who has the government of a navy, and the hearing of all maritime causes.

In our navy besides the Admiral in chief, there are the Vice-admiral who commands the second squadron; and the Rear-admiral, who commands the third division The Admiral carries his flag at the main; the Vice-admiral, at the fore top-mast head; and the Rear-admiral at the mizen. The admiral ranks with generals in the army.

357. A Captain commands a ship of the line of battle, or a frigate carrying twenty or more guns.

He is not only answerable for any bad conduct of the military government, and equipment of the ship which he commands, but also for any neglect of duty.

A Lieutenant, an officer next in rank and power to a captain, in whose absence he commands, musters the men at quarters; visits the ship during the night watches; exercises the men in the use of small arms. First-rates have six lieutenants; a sixth-rate has only one.

Midshipmen, generally youths appointed by the captain of the ship, second the orders of the superior officers, and assist in all duties on board or ashore. In a first-rate there are twenty-four of these, in inferior rates from eight to four.

A Pilot conducts the ship into harbour through intricate channels. This is properly a coasting pilot; one for the high seas can use the quadrant, take observations, and steer a ship from port to port.

The Purser receives the victuals, takes care they be good, and regularly served out to the ship's company. According to the Purser's books the men receive their pay.

The Steward acts under the purser.

The Victualler furnishes the ship with provisions and stores.

The Clerk sees that nothing be wasted and keeps a journal of the loading of a merchant ship, &c. the bargains, purchases, and sales the ship makes from its departure; the consumption of provisions, and every thing relating to the expense of the voyage. In small vessels, the master or mate is also clerk. A mate is the second in subordination; as the master's mate.

The Surgeon and Chaplain resemble the same officers in the army.

358. Marines have nothing to do in working the ship, but defend it in war, and attack the enemy when fighting. There is generally a company on board each ship, about forty in number, under a captain and two lieutenants. The present establishment of marines amounts to more than 30,000. Their principal stations are at Chatham, Woolwich, and Portsmouth. In a sea-fight, their small arms are of very great advantage, in scouring the decks of the enemy, and when they have been long enough at sea, they must be infinitely preferable to seamen, if the enemy attempts to board by raising a battalion with their fixed bayonets.

359. Officers of the navy are, the treasurer who receives monies out of the exchequer, to pay charges of the navy. The controller who attends and controls all payments of wages, knows all the rates of stores, examines and audits all accounts. The surveyor knows the state of all stores, sees all wants supplied, estimates repairs, &c. and at the end of each voyage, audits and states all accounts. The clerk of the acts, records all orders, contracts, bills, warrants, &c.

Navy-Bills, or victualling-bills, are orders for the payment of money, issued by the commissioners of the navy on the treasury of the navy, in payment for stores, &c. furnished by contract for the use of his Majesty's dock yards, and the navy. These bills since 1796, are negotiated like bills of exchange, payable at ninety days after date, and bearing interest at 3½d. per. cent. per diem.

The privileges conferred on sailors are much the same as on soldiers, with regard to relief, when maimed, wounded, or superannuated. Greenwich Hospital receives such seamen as are disabled from further service, and provides for the widows and children of such as are slain.

SECTION VII.

TELEGRAPHS.

360. It immediately follows military and naval tactics, that we give the reader some idea of telegraphs, those modes of quick and certain communication between one place and another.

The telegraph, though brought into general use by circumstances arising from the French Revolution, is of great antiquity, for the principle appears to have been known from the earliest ages, as the ancient Greeks used signals to convey information to distant friends. The news of the burning of Troy was conveyed to Greece by means of telegraphic signals, else how could that event be known in that country soon after it had happened?

The Chinese, when they send couriers on the great canal, or to have every thing prepared when any great man travels, make signals by fire, from one day's journey to another. Most barbarous nations used, formerly, to give the alarm of war, by fires lighted on hills, or rising grounds. Various modes have been adopted for communicating intelligence by signals for every letter in the alphabet, which are observed by telescopes, and repeated at the respective stations. Both day and night telegraphs have been proposed by different writers, and others have insisted on the adoption of a vocabulary in which every sign should represent a word, instead of a single letter as now practised.

The late telegraph, set up by government in a chain of stations from the admiralty to the sea-coast, consists of six octagonal boards; each of which is poised upon an axis in a frame. And this is done in such a manner, that the board can be either placed vertically, so as to appear with its full size to the observer at the nearest station, or it becomes invisible to him, by being placed horizontally, so that the narrow edge alone is exposed, which edge is invisible from a distance. These six boards make thirty-six changes by the most plain and simple mode of working; and will make many more if more were necessary. By a change in the position of one of these octagonal boards, any letter may be made, and in certain positions, a variety of things may be signified, according to the will of the persons at the two extreme posts, employed in making the signals. Thus one board being in an horizontal position, and the others shut, or in a perpendicular situation, may denote the letter *a*; two only being in an horizontal position may give the letter *b*: three in the same manner the letter *c*, and so on. As there may be made as many changes with these boards, as with the same number of bells, the letters of the alphabet may be made with ease, and a sufficient number of signals may be formed for extraordinary purposes.

These have been supplanted by a mast or pole at each station in which are fixed arms that move by pullies and cords;

and according to the angle these arms make with the pole so is the word conveyed.

Knight Spencer's Anthropo-Telegraph consists of two circular disks, of basket work, about eighteen inches in diameter, painted white, with a black ball in the centre of each. These are held by the person to make the signals, one in each hand. By displaying one or both, according to the signal intended at different angles; all necessary information, orders, and commands, may be conveyed by the commanders of armies to every part of their line, &c. This invention was rewarded by the Society for the Encouragement of Arts and Manufactures, with their silver medal, and is described at lengh in their Transactions for 1809, but no general officer has yet reduced it to practice.

The Camp-Telegraph, consists, for day signals, of three flexible balls mounted on staves about ten or twelve feet in height, one of which is distinguished by being double, and used as a centre point; the other two are carried to different distances, to the right or left of the centre point, according to the intended signal. This invention is both simple and portable, the whole apparatus not being more cumbrous than three halberts, or pikes. Questions have been asked by it, and answers obtained, frequently, at the distance of six miles within the space of three minutes. But the most important part of the invention is, that by which night signals are made. It consists of lights, or lanthorns, constructed with hollow lenses, filled with different coloured fluids, the effects of which are such, that communications both on shore and afloat, may be made, with more certainty, than any hitherto made by day.

Lieutenant Spratt, of the Royal Navy, obtained in 1809, from the Society of Arts, &c. their silver medal for his invention of the homograph, or a method of making signals by sea or land, by means of a white pocket handkerchief held in different positions with the body. It is described at length in the Transactions of the Society, vol. xxvii. p. 163.

Various other telegraphs have been invented by Hooke, Garnett, and Pasley.

To this Class belongs also Coutel's Balloon at the Battle of Fleuris.

361. Coutel, Captain of the Aeronautic corps, was the man who ascended with the Entreprenant Balloon, on the 26th of June, 1794, and who conducted the wonderful and important service of re-

connoitering the hostile armies at the battle of Fleuris, accompanied by an Adjutant and a General. He ascended twice on that day, to observe, from an elevation of 440 yards, the position and maneuvres of the enemy.

On each occasion, he remained four hours in the air, and by means of preconcerted signals with flags, carried on a correspondence with General Jourdan, the Commander of the French army. His intended ascent had been made known to the enemy, who, at the moment the balloon began to take its flight, opened the fire of a battery against the aeronauts. The first volley was directed too low: one ball, however, passed between the balloon and the car, and so near to the former, that Coutel imagined it had struck it. When the subsequent discharges were made, the balloon had already reached such a degree of altitude, as to be beyond the reach of cannon-shot, and the aeronauts saw the balls flying beneath the car. Arrived at their intended height, the observers, remote from danger, and undisturbed, viewed all the evolutions of the enemy; and from the peaceful regions of the air, commanded a distinct and comprehensive prospect of two formidable armies engaged in the work of death.

Colossus of Rhodes, was rather a Light-house, than a Telegraph; but there is reason to suppose it answered both purposes.

362. This enormous building has justly been classed among the wonders of ancient architecture. It was a vast structure of brass or statuary metal, erected in honour of Apollo or the sun, the tutelary god of the island; and answered the purpose of a lighthouse to the mariners, who were sailing to or from the island in the night time. The light proceeded from an immense fire contained in a brass vase held in the uplifted right hand of the Colossus.

Its stride was fifty feet asunder, each foot being placed on a rock at this distance from each other, and which bounded the entrance into the haven: its height, according to Pliny, was not less than a hundred and five feet, or seventy cubits; and hence ships of considerable burden were capable of sailing between its legs. It is said to have been erected by the Rhodians with the money produced by the sale of the engines of war which Demetrius Poliorcetes employed in fruitlessly besieging the city for a twelvemonth, and which he gave to them upon his reconciliation. Pliny affirms that it was commenced by Chares of Lindus, a disciple of Lysippus, and finished upon his death by Laches of the same town. It was thrown down by an earthquake sixty years after its completion. As a proof of the immensity of this brazen statue, it is only necessary to observe, that the fingers of it were as large as the body of a full grown man, and the thumb so thick, that few men with outstretched arms were able to encompass it.

CHAPTER XVI.

PHYSICS.

SECTION I.

GENERAL PROPERTIES OF MATTER.

363. Every being or substance that exists is made up of *matter*, whose properties we can investigate, though of itself we can know nothing. Now it is the property of some kinds of matter to act upon our senses immediately, of others, only by the perceptible effects they produce upon other bodies. And we do therefore arrange under the former all sorts of matter as are capable of being seen, as wood, stone, &c.; and under the latter, such species of matter as prove their existence only by their effects upon other bodies, as the atmospheric air, gasses, &c.

364. The properties of matter are *solidity*, or *impenetrability*, *divisibility*, *mobility*, *and inertia*.

Solidity is that property by which two bodies cannot occupy the same place at the same time.

If a piece of wood, or stone, occupy a certain space, before you can put another body into that space, you must first remove the stone or wood: and though fluids do not appear at first to offer such resistance, yet, in proper circumstances, they will be found to retain this property in an equal degree.

Put some water into a tube closed at one end, and insert into it a piston, or a piece of wood or metal, that perfectly fits the inside; you will find it impossible, by any pressure, to get the piston to the bottom without breaking the tube.

If you try the same experiment with the tube empty, as it is called, but in reality filled with air, you will find the same impossibility of pushing the piston to the farthest end of the tube.

Hence, both water and air, and all other fluids, are equally impenetrable, in this sense of the word, with a piece of marble or steel.

By solidity or impenetrability, in common language, is understood the property of not being easily separated into parts: and, therefore, we must be careful not to confound this meaning of the term with the property we have just mentioned.

365. Divisibility is that property by which matter is capable of being separated into parts which may be removed from each other.

This divisibility is evident in bodies of a sensible magnitude: every one knows that they may be divided into 2, 4, 10, or 1000 parts; nor can we ever, by subdividing, arrive at a part so small, but we can conceive that it consists of two halves.

If a grain of gold be melted with a pound or 5760 grains of silver, and a single grain of the mass be dissolved in diluted nitric acid, the gold, which is only the 5761st part of the whole, will fall to the bottom and be visible, but the silver will be dissolved in the acid.

If a bar of silver be gilt, and afterwards drawn into wire, as is done in the manufacture of gold lace, by passing it successively through holes of various magnitudes in plates of steel, the surface will be prodigiously augmented; but it will still be gilded, so as to preserve an uniform appearance, even when examined with a microscope.

In addition to these experiments we may observe, that there are animalculæ so small, that many thousands of them taken together, are smaller than the point of a needle. Mr. Lewenhoeck informs us, that there are more animals in the milt of a cod-fish, than there are men on the whole earth, and a single grain of sand is larger than four millions of these animals. Moreover, a particle of the blood of one of these animalcule has been found, by calculation, to be as much smaller than a globe of the $\frac{1}{10}$th of an inch in diameter, as that globe is smaller than the whole earth.

The natural divisions of matter are still more wonderful. In odoriferous bodies a surprising subtilty of parts is perceived: several bodies scarcely lose any sensible part of their weight in years, and yet continually fill a very large space with odoriferous particles. Thus writing paper put into a drawer in which musk is kept will preserve the smell for years. The purest musk is said to be that which is brought from Patna, in the dominions of the Great Mogul, where it is collected from various parts of the interior of the country. It is imported into Europe in bags, each of which is about the size of a pigeon's egg, well filled, and covered with short brown hair.

Musk was formerly much used as a perfume. It is now chiefly in repute as a medicine in spasmodic, convulsive, and other complaints; and when properly given is thought a remedy of great service. So powerful is the scent of this drug that the smallest particle of it will perfume a very considerable space; and when the bags are fresh, if one of them be opened in a close apartment, every person present is obliged to cover his mouth and nose with several folds of linen to prevent suffocation.

366. Mobility is that property of matter by which it is capable of being moved from one part of space to another.

367. Space is only an abstract idea; it consists of parts, but has no bounds; and when we move a body through it, that body moves in consequence of sufficient force having been applied to it. Now this is applied to inert bodies, as well as those which have the power of volition or will; a stone may be thrown at will, and a dog may run after it of his own accord.

368. Inertia, or *Inactivity*, is the tendency which bodies have to continue in the same state into which they are put, whether of rest or motion, unless prevented by some external force.

No one can suppose that matter can begin to move of itself, unless it be in some way acted upon; but it does not appear so evident that it has a tendency to continue in motion for ever. Most people are apt to suppose that all matter has a propensity to fall from a state of motion into a state of rest; because we see all the motions upon the earth gradually decay, and at last totally cease. But this is owing to the resistance of the air, and to friction: for if these be diminished the body will move longer: and if they could be removed altogether, the body would continue for ever in motion. But take some familiar experiment. For instance,

A marble shot from the fore finger and thumb, would run but a small distance on a carpet: its motion would be continued much longer on a level pavement; and longer still on fine smooth ice, such as might cover the bosom of the Arar. In this case, the friction is greater on the carpet, and least on the ice. And if, as we have observed, the friction were entirely destroyed, as also the resistance of the air, the marble once put in motion by a school-boy, would continue in that state for ever.

If a man be standing in a boat while it is pushed off from the shore, he will be in danger of falling backwards; but he will gradually acquire the motion of the boat; and on the contrary, if it be suddenly stopped, he will fall forwards, because his tendency will then be to continue in the same state of motion. Innumerable instances of the same kind, in common life, may be observed.

369. EXTENSION though by some considered a property of matter, is, properly speaking, but another name for space; space is extended every where, and what is extension if it be not space?

SECTION II.

MECHANICAL AFFECTIONS OF MATTER.

370. By ATTRACTION is meant the tendency that bodies have to approach each other, whatever be the cause of such tendency.

371. There are five kinds of attraction: viz. the attraction of *cohesion;* of *gravitation;* of *electricity;* of *magnetism;* and of *chemical affinity.*

372. *Defin.* The attraction of *Cohesion* is that by which the constituent particles of bodies are kept

together. By this principle they preserve their forms and are prevented from falling to pieces.

The attraction of cohesion takes place between bodies or atoms, only when they are at very small distances from each other.

If two leaden bullets be scraped very clean, and squeezed together, they will adhere so firmly as to require a considerable force to separate them.

If two globules of quicksilver be placed near each other they will run together and become one large drop.

By the attraction of cohesion are formed stones, metals, woods, salts, and every thing that may be denominated a body. Petrifactions, porcelain, pottery, bricks, glass, cements, artificial stones, and plastic earthy compositions, which preserve their figure in drying, are all children of this great agent; and as this power is much greater in some bodies than in others, there arises an infinite variety in the strength, weight, and texture of metals. It is upon this principle also, that carpenters and cabinet makers use glues; that braziers, tinmen, and plumbers solder their metals, and that smiths unite different bars of iron, by the agency of heat.

The result of sundry experiments, made by professor Musschenbroek, to show the cohesive power of different solids, may be seen in the following table. In estimating the absolute cohesion of solid bodies, he applied weights to separate them, according to their length; the pieces of wood which he used were parallelopipedons, each side of which was $\frac{27}{100}$ths of an inch, and the metal wires made use of were $\frac{1}{10}$ths of a Rhinland inch in diameter, and they were drawn asunder, by the following weights:

	lb.		lb.
Fir	600	Copper	299¼
Elm	950	Brass	360
Alder	1000	Gold	500
Oak	1150	Iron	450
Beech	1250	Silver	370
Ash	1250	Tin	49¼
Lead	29¼		

373. *Defin.* *Capillary* attraction is reckoned a species of cohesion, and the suspension of the fluid in the capillary tubes of plants is owing to the attraction of the ring of the tube contiguous to the upper surface of the fluid.

Some persons think that bodies derive certain characteristic properties from the various degrees of cohesion which their parts exert; hence the solidity of some kinds of matter and the fluidity of others.

As the parts of a body are kept together by attraction, this power is overcome when a body is broken. Hence the reason of soldering metals, glueing wood, &c. Hence, also, when the particles or moleculæ, of which a body is composed, so adhere the one to the other, that they cannot be separated without effort, we say of such a body that it is solid;—such are metals, stone, wood, &c. Hence, also, such substances as are composed of particles adhering very slightly, and which, yielding to any small effort, are easily moved among each other, we term fluids: such are water, beer, air, &c. These properties may result from the different figures of the particles, and the greater or the less degree of attraction, consesequent thereupon.

Elasticity may arise from the particles of a body, when disturbed, not being drawn out of each other's attraction; as soon, therefore, as the force which acts upon it ceases, they restore themselves to their former position.

374. The attraction of *gravitation* is one of the most universal principles in nature. It is that force by which distant bodies tend towards each other. By gravity, a stone dropped from a height falls to the earth; by it the heavenly bodies are kept in their orbits; and hereby all terrestrial bodies tend towards the centre of the earth. By it, the planets tend towards the sun, and towards each other, as well as the sun does to them.

From this attraction arises all the motion, and consequently all the changes that take place, in the grander portions of the universe. By this, heavy bodies descend, and light ones ascend: by this projectiles are directed, and rains fall: rivers glide, the ocean swells, and the air presses upon different bodies. By capillary attraction, water or other liquids will ascend in sugar, sponge, and all porous bodies. It is thus denominated, from the property which tubes (scarcely capable of admitting a hair) have, of causing water to stand above its level.

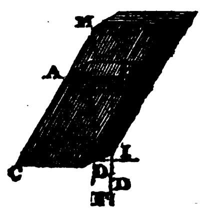
Obs. Under the article Physical Astronomy, the laws of motion, and the doctrines of attraction and gravitation have been amply explained. It will here only be necessary, therefore, to illustrate what philosophers understand by the centre of gravity, as applicable to the purpose of common life.

SECTION III.

THE CENTRE OF GRAVITY OF BODIES AND OF ANIMALS.

375. If you balance any body on your finger, as a Gunter's scale, for example, it will rest in a horizontal position when the figure 12 is over your finger. That point, therefore, on which the scale is exactly balanced, is called the centre of gravity.

376. Again, if you place a body upright as a pillar, it will remain perpendicular, provided the line of direction falls exactly in the centre of its base.



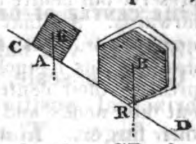
Thus, the inclining body ABCD, whose centre of gravity is E, stands firmly on it base CDIK, because the line of direction EF falls within the base. But suppose ABCD were the first stone of a column, and that we had not placed it perfectly on the base, and were then to lay another block of stone upon it, as ABGH, the centre of gravity would be raised to L, and then as the *line of direction* LD falls without the base at D, the centre of gravity is not supported, and the whole weight must fall just as the Gunter's scale would slide off your finger if you attempted to balance it at the figures 13 or 11.

377. Upon the principle here laid down, the safety coaches now in use have been built. The base of these coaches is made as broad as possible, the line of direction is brought as near their middle as possible.

378. In this too consists the great difficulty of posture-masters and rope-dancers.

The dancer on the rope balances himself by a long pole loaded with lead, and keeps his eye steadily upon some one point exactly parallel to the rope, by which he can see whether his centre of gravity is either on one side or the other of his slippery foundation, and if any irregularity takes place he rectifies it by his balancing pole.

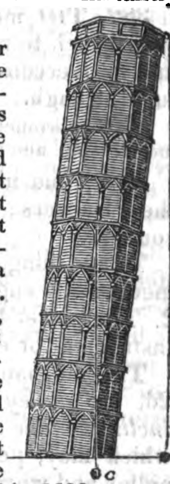
379. If a plane be inclined on which a heavy body is placed, the body will slide down the plane, while the line of direction falls within the base; but it will roll down when this line is beyond the base.



Thus the body E will only slide down the plane CD, but the body B rolls down the plane CD; because the line of direction BR is beyond the base.

Hanging Towers of Pisa and Bologna.

380. In old buildings where the whole fabric is closely bound together, it may occur that a part may overhang the base, and yet that part not fall; but if the centre of gravity of the whole building were brought without the base, ruin would instantly ensue.



The famous campanill or hanging tower of Pisa, is erected in a square, close to the great church of the same name. It is composed wholly of white marble, and was built for the purpose of containing the bells. Its height is about two hundred feet, and its inclination nearly fifteen feet from the perpendicular, but the plummet C falls within the base, and therefore it stands. The cause of this very extraordinary inclination is supposed to be a want of care in laying the foundation. The two towers of Bologna, in Italy, close beside one another, hang several feet beyond the perpendicular, and seem to beholders as if ready to fall; but as the whole building firmly adheres together, and as the centre of gravity is still above the base, they are perfectly secure. They must have been long in this state, as they are mentioned in the poems of Dante who died in 1586.

381. In animals the centre of gravity is preserved when the line of direction falls within the base of their feet.

In ascending a stair or a steep hill we bend our body forwards; in descending we lean backwards, as it were, to preserve our centre of gravity. In carrying a burden we lean forwards. All that is applicable to man, is applicable to quadrupeds, birds, and fishes. The mule on the Andes will drop on his haunches and slide down a rock; birds to preserve their centre of gravity flying are obliged to stretch out their necks and make great use of their tails; fishes of their fins, &c. In short, the economy of nature is as marvellous in this matter as in the exact system of the world.

CHAPTER XVII.

MECHANICS.

382. THE mechanical powers are simple engines, with which to raise weights, to move heavy bodies, and to overcome resistances, that are above our natural strengh.

The importance of these mechanical powers to society is incalculable, and a knowledge of them indispensable.

Every machine is composed of one or more of these powers; and sometimes of several of them combined.

Three things are to be considered in treating of mechanical engines, 1. The weight to be raised. 2. The power by which it is to be raised. 3. The instrument or engine by which this is to be effected.

The mechanical powers are six: 1st, the *lever*; 2d, the *pulley*; 3d, the *wheel* and *axis*; 4th, the *inclined plane*; 5th, the *wedge*; and 6th, the *screw*; which may, perhaps, be reduced to two; for the pulley and wheel are only assemblages of levers, and the wedge and screw are inclined planes.

Of the Lever.

383. The lever, the simplest of all machines, is only a straight bar of iron, or wood, supported on, and moveable round, a prop, called the fulcrum.

In the lever, there are three circumstances to which we must principally attend.

1. The fulcrum or prop by which the lever is supported, or on which it turns as an axis, or centre of motion.
2. The power to raise and support the weight: and,
3. The resistance or weight to be raised or sustained.

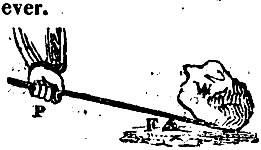
The point of suspension is that point where the weight really is, or from which it hangs freely.

The power and the weight are supposed to act at right angles to the lever, except otherwise expressed.

There are three sorts of levers, according to the different situations of the fulcrum, or prop, and the power, with respect to each other.

1. When the prop is placed between the power and the weight.

A lever of *this kind* is principally used for loosening stones; or to raise weights to small heights, to get ropes under them, or other means of raising them to still greater heights: it is the most common species of lever.

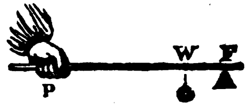


Example. If a stone (W), weighing 500 pounds, is to be raised one foot by a man acting at (P), who can only lift 100 pounds, he cannot raise it, unless he contrive to make his arm move five feet while the stone moves only one foot; because $100 \times 5 = 500 \times 1$; therefore to effect this the arm of the lever (P F) must be five times as long as the arm between F and the weight, in order that the power and weight may balance each other.

This increase of motion in the arm is effected by the lever; because the motion of one end is in the same proportion to the motion of the other, as the distance of the two ends are from the fulcrum.

If a lever, six yards in length, call it, if you please, an eighteen feet plank, be laid on a fulcrum (P), at one yard from one end and the aforesaid stone be fixed to that end of the plank or lever, the hand which pulls at the long, or five yards' end (P) of the lever, moves over five times the space that the other end does, consequently, though pulling but 100 pounds, it will balance 500 pounds at the short end of the lever.

2. When the prop is at one end of the lever, the power at the other, and the weight between them.



The advantage gained by the lever, as in the first, is as great as the distance of the power (P) from the prop (F), exceeds the distance of the weight (W) from it.

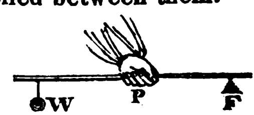
This lever shews the reason why two men carrying a burthen between them, as a cask upon a pole, may bear unequal shares of the weight according to their strength; for the nearer either of them is to the burthen, the greater share he will bear of it: their shares of its weight will, in fact, be to either of them in the inverse proportion of his distance from it.

If the pole be eight feet long, and a cask be slung directly at its half length, at one end of the pole each of the men will bear *56lbs.* weight, supposing the cask to weigh one *cwt.*; but if it be placed five times nearer the one man than the other, the former will bear five times as much weight as the latter.

This is likewise applicable to the case of two horses of unequal strength so yoked, that each horse may draw a part in proportion to his strength. This is done by so dividing the beam they pull, that the point of attraction may be as much nearer to the stronger horse than to the weaker, as the strength of the former exceeds that of the latter.

To this kind of lever may be reduced oars, rudders of ships, cutting knives which are fixed at one end, &c.

3. When the prop is at one end, the weight at the other, and the power applied between them.



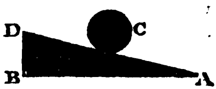
In this lever we suppose the power and weight to change places, the power (P) is between the weight (W), and prop (F). And here, that there may be a balance between the power and the weight, the intensity of the power must exceed the intensity of the weight as much as the distance of the weight from the prop exceeds the distance of the power.

A ladder, raised by the strength of a man's arms, represents a lever of this kind, the fulcrum is the end fixed against the wall, or upon which another man stands: the weight is at the top part of the ladder, and the power is the strength of the man applied to raise it.

The wheels in a clock, and in watch-work, are levers of this kind, because the power that moves them acts near the centre of motion, by a pinion, and the resistance it has to overcome, acts against the teeth at the circumference.

Of the Inclined Plane.

384. The Inclined Plane, is merely a plane surface inclined to the horizon; but a mechanical power of great use in moving weights from one level to another; as for example, for rolling up casks, wheel-barrows, &c. It is formed by placing boards or earth in a sloping direction.



The force wherewith a body (C) descends upon an inclined plane, is to the force of its absolute gravity by which it would descend perpendicularly in free space, as the height (B D) of the plane is to its length (D A).

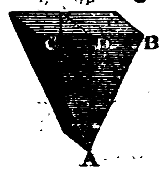
Thus, when a plane is inclined to the horizon one-third of its whole length, any body will be kept from rolling down that plane, by a power equal to a third part of the weight of the body: if D A be six feet and B D two feet; then if C be six pounds, a power of two pounds will support it: if the height of the plane be equal to half its length a power equal to half the weight of the body will support it: but a plane, perpendicularly situated, ought not to come under the denomination of this article, because the plane in such a direction contributes nothing to the support or hindrance of the falling body, which descends with its whole force of gravity, unless prevented by a power equal to its whole weight.

It is obvious from the foregoing illustrations, that the less the angle of elevation, or the gentler the ascent is, the greater will be the weight which a given power can draw up; for the steeper the inclined plane is, the less does it support of the weight; and the greater the tendency which the weight has to roll, consequently the more difficult for the power to support it: hence the advantage gained by this mechanical power, is as great as its length (A D) exceeds its perpendicular height (B D).

To the inclined plane may be reduced all *hatchets, chisels*, and other *edged tools*, which are sloped on one side only.

Of the Wedge.

385. The wedge is merely two equally *inclined planes* united at their bases, and the advantage gained, by this mechanical power, is in proportion as the length of the two sides, A B, A C, of the wedge, is greater than the back B C, or as the length on one side A B, is greater than half the back B D.



Wedges are used in splitting wood, stones, &c. When wood does not cleave at any distance before the wedge, there will be an equilibrium between the power, driving the wedge downward and the resistance of the wood acting against the sides of the wedge, when the power is to the resistance as half the thickness of the wedge at the back is to the length of either of its sides; because the resistance then acts perpendicularly to the sides of the wedge. But when the resistance on each side acts parallel to the back, the power that balances the resistance on both sides, will be as the length of the whole back of the wedge is to double its perpendicular height. When the wood cleaves at any distance before the wedge (as it generally does), the power of impelling the wedge will not be to the resistance of the wood, as the length on the back of the wedge is to the length of both its sides, but as half the length of the back is to the length of either side of the cleft, estimated from the top or acting part of the wedge.

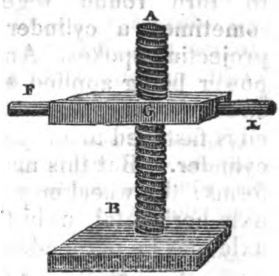
The wedge is a very great mechanical power, in splitting wood and rocks, which it would be impossible to effect by the lever, wheel and axle, or pulley: the force of the blow or stroke upon the wedge, shakes the cohering parts of the most compact body of stone, and makes them separate more easily.

Most of the instruments used in the common purposes of life are to be referred to the principle of the wedge.

Of the Screw.

386. The screw is an inclined plane used with a lever or winch to assist in turning it. It is a com-

pound engine of great force, either in pressing bodies together, or in raising great weights. The screw may be conceived to be made by cutting a piece of paper in the form of an inclined plane, and then wrapping it round a cylinder; when the edge of the paper will form a spiral line round the cylinder, which will answer to the thread of the screw.

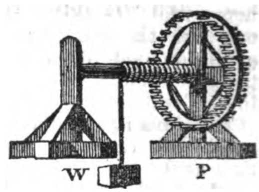


The advantage gained by this mechanical power is in proportion as the circumference of the circle made by the lever or winch F L, is greater than the interval or distance between the spirals or threads of the screw A. To estimate the force then, of this machine, let us suppose that I desire to screw down the press G upon B, every turn I make once round with both handles, I shall drive the press only one spiral nearer to B; so that if there are twenty-two spirals, I must make twenty-two turns of the handles F L before I come to the bottom. In pressing down the screw I act with a force as much superior to the resistance of the body I desire to press, as the circumference of the circle, which my hands describe in turning the machine, exceeds the distance between the two little spirals of the screw.

Thus, supposing the distance of the spirals to be half an inch, and the length of the winch thirty-six inches, the circle described by the handle of the winch, when the power acts, will be two hundred and twenty-eight inches nearly, or about four hundred and fifty-six half-inches; and consequently, four hundred and fifty-six times as great as the distance between the spirals: and therefore a power at the handle whose intensity is equal to no more than a single pound, will balance four hundred and fifty-six pounds, acting against the screw; and as much additional force as is equal to overcome the friction, will raise the four hundred and fifty-six pounds; and the velocity of the power will be to the velocity of the weight, as four hundred and fifty-six is to one. Hence it appears, that, the longer the winch is, and the nearer the spirals are to each other, so much the greater is the force of the screw.

Almost all kinds of presses, common cork-screws, &c. act upon the principle of this mechanical power. When the screw acts in a wheel, it is called a *perpetual screw.* Screws properly applied, are used to support large buildings whilst the foundations are mending or renewed.

Of the Wheel and Axle.



387. The wheel and axle consist of a wheel fixed to an axle, or cylinder, so as to turn round together: sometimes a cylinder with projecting spokes. And the power being applied at the circumference of the wheel, the weight (W) to be raised is fastened to a rope which coils round the axle or cylinder. But this machine is made in a variety of forms: the wheel may be perpendicular (P) and the axle horizontal, as in the diagram before us; or the axle may be perpendicular and the wheel horizontal.

The circumferences of different circles bear the same proportion to each other, as their respective diameters; consequently the advantage gained, by this mechanical power, is in proportion as the circumference of the wheel is greater than that of the axis, or as the diameter of the wheel is greater than the diameter of the axis. Hence the velocity of the power will be to that of the weight, as the circumference of the wheel is to that of the axis: and that, the power and the weight being in equilibrio, the power must be to the weight in the inverse ratio of the circumference of the wheel to that of the axis.

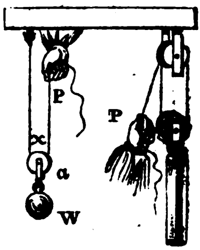
Suppose a water wheel twelve feet diameter turn an axle of one foot, the power acting at the circumference of the large wheel, moves over twelve times the space which the circumference of the axle moves: hence twelve *cwt.* may be raised with the power of one *cwt.*

The wheel and axis 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 diameter of the wheel, and the diameter of the axis. From this it is evident, that the longer the wheel, and the smaller the axis, the stronger is the power of this machine: but the weight must rise slower in proportion.

A capstan is a cylinder of wood with holes in it, into which are put bars, or levers, to turn it round: these are like the spokes of a wheel without a rim. All windlasses, cranes, mills, windmills, and watermills, are framed on the principle of this machine; and the power whatever it be is applied to the circumference of a large wheel, whose circumference moves in consequence, perhaps ten miles an hour, while its axle, one tenth of its diameter, moves but one mile an hour; consequently the strength of one man at the circumference, will be equal to that of ten men at the axle: and when the axle is turned by a winch fastened to it, it will be more powerful, in proportion to the largeness of the circle it describes, compared with the diameter of the axle.

Of the Pulley.

388. The pulley is a wheel turning on an axis, with a drawing rope passing over it: the wheel (*x*) is usually called a *sheeve*, and is so fixed in a *box* or *block* (*a*), as to be moveable round a pin passing through its centre.



Pullies are of two kinds; 1. *Fixed*, as the upper pulley on the right hand side of the diagram; and 2. *Moveable*, as the lower ones, which rise and fall with the weight.

The *fixed pulley* is used only to change the direction of a power, as in raising a weight to any height, without moving from the place in which one is, as a stone to the top of a building: it also enables several men to apply their strength together to the weight by means of the rope.

The *moveable pulley* doubles the power, and a man (P) may raise twice as much by his physical strength; whence by increasing the number of such pullies, the force may be increased in any ratio whatever. The advantage gained by it, is as two to one; conquently, a power of 10*lbs.* exerted by the hand will balance a weight of 20*lbs.*

The reason of this is evident, for in raising the weight one inch, one foot, or one yard, both sides of the rope must be shortened as much; that is to say, the hand must move through two inches, feet, or yards, which shews that the space through which the power moves, must always be in proportion to the advantage gained. In general, the advantage gained by pullies is found by multiplying the number of pullies in the lower block by two. A pair of blocks with a rope is called a tackle.

Of compound Machines.

389. Though any one of the mechanical powers is capable of overcoming the greatest possible resistance, in theory; yet, in practice, if used singly, for producing great effects, they are unwieldy and unmanageable, it is found more advantageous to combine them; by which means the power is more easily applied, and many other advantages obtained. In all machines, simple as well as compound, what is gained in power is lost in time.

Suppose a man, by a fixed pulley, raises a beam to the top of a house in two minutes, he will be able to raise six beams in twelve minutes: but by means of a tackle, with three lower pullies, he will raise the six beams at once, with the same ease that he raised one; but he will be twelve minutes about it; the work is performed in the same time, whether the mechanical power is used or not. But the convenience gained by the power is very great; for if the six beams be joined in one, they may be raised by the tackle, though it would be impossible to move them by the unassisted strength of one man.

Consequently, if by any power you are able to raise a pound with a given velocity, it will be impossible, by the help of any machine, without increasing the power, to raise two pounds with the same velocity: yet, by the assistance of a machine, you may raise two pounds with half that velocity, or even one thousand with the thousandth part of that velocity; but still there is no greater quantity of motion produced, when a thousand pounds are moved, than when one pound is moved; the thousand pounds moving proportionally slower.

No real gain of force is, therefore, obtained by mechanical contrivances; on the contrary, from friction, and other causes force is always lost; but by machines we are able to give a more convenient direction to the moving power, and to apply its action at some distance from the body to be moved. By machines also, we can so modify the energy of the moving power, as to obtain effects which it could not produce without this modification.

In machines composed of several of the mechanical powers, the power will be to the weight, when they are in equilibrio, in a ratio formed by the multiplication of the several proportions which the power bears to the weight in every separate mechanical power of which the machine consists.

Suppose a machine, for instance, composed of the axle in the wheel, and pullies: let the axle and wheel be such, that a power consisting of one-sixth of the weight will balance it; and let the pullies be such, that by means of them alone, a power equal to one-fourth of the weight would support it: then, by means of the axle in the wheel, and the pullies combined, a power equal to one-fourth of one-sixth, that is, $\frac{1}{24}$ of the weight, will be in equilibrio with it.

In contriving machines, simplicity ought to be attended to; for a complicated machine is more expensive, and more apt to be out of order, and the friction is in proportion to the number of rubbing parts.

Whatever be the construction of a machine, the advantage gained by it will be in proportion as the velocity of the power is to that of the weight; and so that this is obtained in the greatest degree that circumstances will admit, or are necessary, then the fewer parts the better.

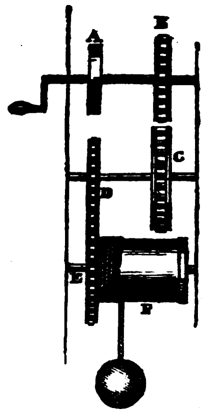
The velocity of a wheel is to that of a pinion, or smaller wheel driven by it, in proportion to the diameter, circumference, or number of teeth in the pinion to that of the wheel.

Thus, if the number of teeth in a wheel be 60, and those of the pinion 5, then the pinion will go 12 times round while the wheel goes once round, because 60 ÷ 5 give 12 for a quotient. Hence, if you have any number of wheels acting on so many pinions, you must divide the product of the teeth in the wheels by the product of those in the pinions; and the quotient will give the number of turns of the last pinion in one turn of the first wheel. Thus, if a wheel of 48 teeth acts on a pinion of 8, on whose axis there is a wheel of 40, driving a pinion of 6, carrying a wheel of 36, which moves a pinion of 6, carrying an index; then the number of turns made by the index will be found in this manner: $\frac{48}{8} \times \frac{40}{6} \times \frac{36}{6} = \frac{69120}{288} = 240$, the number of turns which the index will make while the wheel goes once round.

Any number of teeth on the wheels and pinions having the same ratio, will give the same number of revolutions to an axis: thus, $\frac{64}{10} \times \frac{50}{8} + \frac{36}{6} = \frac{115200}{480} = 240$, as before. It therefore depends on the skill of the engineer, or mechanic, to determine what numbers will best suit his design.

It is evident that the same motion may be performed, either by one wheel and pinion, or by many wheels and pinions, provided the number of turns of all the wheels bear the same proportion to all the pinions which that one wheel bears to its pinion.

When a wheel is moved immediately by the power, it is called a *leader*; if there is another wheel on the same axis, it is called the *follower*.



Thus A being moved immediately by the power is to be considered a *leader*, and B a follower; the wheel C driven by B becomes a *leader*, and D a follower; E is a leader and the cylinder F a follower. Sometimes the same wheel acts both as a leader and a follower. Thus if the ends of the cylinder were reversed, and the teeth of the wheel E worked in the teeth of C, then would C be a follower to B and a leader to E: that is, when these wheels work in succession, the middle one is both a leader and a follower. Therefore, as to multiply both the divisors and dividend by the same number, does not alter the quotient; in mechanical calculations, every wheel that is both a leader and a follower, may be entirely omitted.

The power of a machine is not at all altered by the size of the wheels, provided the proportions to each other are the same. Formerly the wheels of engines being mostly of wood, were of a large size, on account of strength; but now that cast-iron wheels are so easily made, the size of them is very much diminished, and they occupy much less room.

Of Fly Wheels.

390. In all machines, the moving power acts with more or less irregularity, being sometimes stronger, and at other times weaker. But to correct this, and render the motion uniform, an additional part, called a *fly*, is applied.

This fly is generally either a heavy wheel, or a cross bar loaded with equal weights, made to revolve about its axis, and keep up the force of the power by distributing it equally in all parts of its revolution: for on account of its inertia, a small variation in force does not sensibly alter its motion; whilst friction, and the resistance of the machine, prevent it from accelerating. If the motion of the machine slackens, it helps it forward: if it moves too fast, it will keep it back. The truth of this is easily understood from considering the inequality of the motion in a clock, when the pendulum is off, and how very uniformly it goes when regulated by a pendulum, which here acts as a fly. Every regulating-wheel should be fixed upon that axis where the motion is swiftest, and should be heavy when the motion is designed to be slow, and light when it is designed to be swift. In all cases, the centre of motion should coincide with the centre of gravity of the wheel. The axis may be either perpendicular, or parallel to the horizon. Fly-wheels, in general, are employed to *equalize* the motion of a machine; they cannot add to its power.

Of Friction.

391. Friction in its primitive sense signifies the act of rubbing two bodies together; in machinery it implies the resistance caused by the motion of the different parts against each other; and in the application of all the mechanical powers, one third is allowed to overcome the *friction* of the surface, and other obstacles to which machines are liable.

If a horizontal plane were perfectly smooth, a body would be free to move upon it in any direction, by the least force applied to it. But however smooth bodies appear to the eye, if you examine their surfaces with a microscope, you will discover numberless inequalities; in consequence of which, the prominent parts of one body fall into the hollows of another, so as to be locked together; and therefore, in moving them over each other, one of the bodies must be raised up, or its prominences broken off: this is a philoso-sophical definition of *friction*.

Friction is greater in bodies, in proportion to their weight or pressure against each other. It does not increase much in proportion to the surface, but in proportion to the velocity of the moving bodies. Wood slides more easily upon the ground, or earth, in wet weather than in dry, and more easily than iron in dry weather, but iron more easily than wood in wet weather. A cubic piece of smooth soft wood, eight pounds in weight, moving upon a smooth plane of soft wood, at the rate of three feet every second, has a friction equal to above two-thirds of its weight. Soft wood upon hard wood, has a friction equal to one-sixth part of its weight: and hard wood upon hard wood, has a friction equal to about one-eighth part of its weight. In wood rubbing upon wood, oil, grease, or black-lead, properly applied, makes the friction two-thirds less. Wheel-naves, when greased, have only one-fourth of the friction they would have if wet. Hence the propriety of so contriving wheel naves as to keep the grease from being dissipated.

When polished steel moves on steel, or pewter properly oiled, the friction is about one-fourth of the weight; on copper or lead, one-fifth; on brass one-sixth; and metals have more friction when they move on metals of the same kind, than on different metals.

The friction of a single lever is very little. The friction of the wheel and axle is in proportion to the weight, velocity, and diameter of the axle; the smaller the diameter of the axle, the less the friction.

The friction of pullies is great, on account of the smallness of their diameters, in proportion to that of their axes; because they often bear against the blocks, and from the wearing of their holes and axles.

In the wedge and screw there is much friction. Screws with sharp threads, have more friction than those with square threads, and endless screws have most.

Men and Horses considered as first Movers.

392. A horse draws with the greatest advantage, when the line of draught is not level with his breast, but inclines upwards, making a small angle with the horizontal plane. When a horse works in a circle, it should not be less than forty feet in diameter. A horse exerts most strength, when drawing horizontally.

In turning a winch, a man exerts his strength in different proportions at different parts of the circle. The greatest force is when he pulls the handle upwards from the height of his knee; and the least, when he thrusts from him horizontally.

The handles at each end of a winch should be put on at right angles to each other, and not opposite, as they often are.

The Mill and Mill Work.

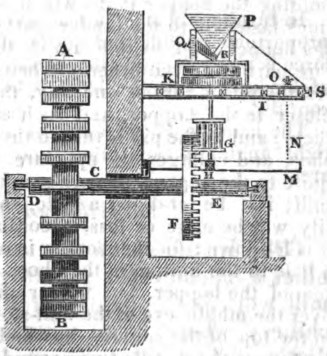
393. In the strictest sense of the word, a mill signifies a machine for grinding corn, though the term mill-work is frequently applied to all kinds of machinery where large wheels are used. They are distinguished into various kinds, either according to the powers by which they are moved, or the uses to which they are applied. Such as *water-mills, horse, wind, corn, fulling, powder,* and *boring-mills,* &c.

To enter into the detail of all these different sorts of mills, would fill a volume, we shall therefore confine ourselves to that most useful machine, the corn-mill.

Formerly, corn was ground only by hand-mills, consisting of two stones, similar to those used in water-mills, but much smaller, the upper one having a piece of wood fixed into it to move it by. They are still used in some parts of Scotland, and are called *querns.* These, however, have given place to water-mills, and wind-mills, which are now commonly used.

394. There are three kinds of water-mills ; *breast, undershot,* and *overshot mills,* according to the manner in which the water is applied to the great wheel. In the first, the water falls down upon the wheel at right angles to the float-boards, or buckets placed all round the wheel to receive it. In the second, which is used where there is no fall of water, the stream strikes the float boards at the lower part of the wheel. In the third, the water is poured over the top, and is received in buckets formed all round the wheel.

We shall describe the corn-mill of the most common sort as follows :



AB is the water wheel, which is generally from eighteen to twenty-four feet in diameter, reckoned from the uttermost edge of any float-board at A, to that of the opposite one at B. The wheel is fixed upon a very strong axis, or shaft C, one end of which rests on D, and the other on E, within the mill-house. On this shaft, or axis, and within the mill-house, is a wheel F, about eight or nine feet in diameter, having cogs all round, which work in the upright staves, or rounds of a trundle G. This trundle is fixed upon a strong iron axis, called the spindle, the lower end of which turns in a brass foot, fixed at H, in a horizontal beam H M, called the bridge-tree ; and the upper end of the spindle turns in a wooden bush fixed into the nether mill-stone, which lies upon beams in the floor I. The top of the spindle above the bush is square, and goes into a square hole in a strong iron cross, called the rynd; under which, and close to the bush, is a round piece of thick leather upon the spindle, which it turns round at the same time as it does the rynd. The rynd is let into grooves in the under surface of the running mill-stone K, and so turns it round in the same time that the trundle G, is turned round by the cog-wheel F. This mill-stone has a large hole quite through its middle, called the eye of the stone, through which the middle part of the rynd and upper end of the spindle may be seen; whilst the four ends of the rynd lie below the stone in their grooves. One end of the bridge-tree which supports the spindle, rests upon the wall, whilst the other is let into a beam, called the brayer, LM. The brayer rests in a mortice at L; and the other end M, hangs by a strong iron rod N, which goes through the floor I, and has a screw-nut on its top at O; by the turning of which nut, the end M of the brayer is raised or depressed at pleasure, and consequently the bridge-tree and the upper mill-stone. By this means, the upper mill-stone may be set as close to the under one, or raised as high from it, as is convenient.

The corn will be ground fine or coarse, according to the distance of the mill-stones from each other. On the top of box which incloses the mill-stone, stands a frame for holding the hopper P, to which is hung the shoe Q, by two lines fastened to the hinder part of it, fixed upon hooks in the hopper, and by one end of the string R fastened to the fore part of it; the other end being twisted round the pin S. As the pin is turned one way, the string draws up the shoe closer to the hopper, and so lessens the aperture between them; and as the pin is turned the other way, it lets down the shoe, and enlarges the aperture. If the shoe be drawn up quite to the hopper, no corn can fall from the hopper into the mill; if it be let down a little, some will fall; and the quantity will be more or less, according as the shoe is more or less let down; for the hopper is open at bottom, and there is a hole in the bottom of the shoe, not directly under the bottom of the hopper, but nearer the lowest end of the shoe, over the middle eye of the mill-stone. There is a square hole in the top of the spindle, in which is put the feeder F; this feeder, as the spindle turns round, jogs the shoe three times in each revolution, and so causes the corn to run constantly down from the hopper through the shoe, into the eye of the mill-stone, where it falls upon the top of the rynd, and is, by the motion of the rynd, and the leather under it, thrown below the upper stone, and ground between it and the lower one. The violent motion of the stone creates a centrifugal force in the corn going round with it, by which means it gets farther and farther from the centre, as in a spiral, in every revolution, until it be quite thrown out; and being then ground, it falls though a spout, called the mill-eye, into a trough.

When too much corn is let into the mill, or when the mill is fed too fast, the corn bears up the stone, and is ground too coarse; and besides, it clogs the mill, so as to make it go too slow. When the mill is too slowly fed, it goes too fast, and the stones, by their attrition, are apt to strike fire. Both which inconveniences are avoided by turning the pin S backward or forward, which draws up or lets down the shoe; and thus regulates the feeding, as is found convenient; the greater the quantity of water that falls upon the wheel, and the heavier the running mill-stone is, the faster will the mill bear to be fed; and consequently it will grind the more. And, on the contrary, the lighter the stone, and the less the quantity of water, so much slower must the feeding be. But when the stone is considerably worn, and become light, the mill must be fed slowly at any rate; otherwise the stone will be too much borne up by the corn under it, which will make the meal coarse.

The power sufficient to turn a heavy mill-stone, is but very little more than what is necessary to turn a light one; for as it is supported upon the spindle by the bridge-tree, and the end of the spindle that turns in the brass foot therein, being but small, the difference arising from the weight is but very inconsiderable in its action against the power or force of the water.

It is natural the corn should be crushed, when it comes to a place where the interval between the two mill-stones is less than its thickness; yet the upper mill-stone being supported on a point which it can never quit, it does not so clearly appear why it should produce a greater effect when it is heavy than when it is light; since, if it were equally distant from the nether mill-stone, it could only be capable of a limited impression. But as experience proves that this is really the case, it is necessary to discover the cause. The spindle of the mill-stone being supported by a horizontal piece of timber, about nine or ten feet long, resting only on both its ends, by the elasticity of this piece, the upper mill-stone is allowed a vertical motion, playing up and down; by which movement, the heavier the stones are, the more strongly is the corn pressed between them.

Both the upper and under mill-stones have channels or furrows cut into them, proceeding obliquely from the centre to the circumference, in order to cut and grind the corn. And these furrows are cut perpendicularly on one side, and obliquely on the other, which gives each furrow a sharp edge; and in the two stones they come, as it were against one another, like the edges of a pair of scissars, and so cut the corn, to make it grind the easier, when it falls upon the places between the furrows. These are cut the same way in both stones, when they lie upon their backs, which makes them run crossways to each other when the upper stone is inverted by turning its furrowed surface towards that of the lower; for if the furrows of both stones lay the same way, a great deal of the corn would be driven onward in the lower furrows, and so come out from between the stones, without being cut or bruised. Also the grinding surface of the under stone is a little convex from the edge to the centre, and that of the upper stone a little concave; so that they are farthest from one another in the middle, and approaching gradually nearer towards the edges. By this means the corn, at its first entrance between the stones, is only bruised; but as it goes farther on towards the circumference or edge, it is cut smaller and smaller, and at last finely ground, just before it comes out from between them.

When the furrows become blunt or shallow by wearing, the running stone must be taken up, and both stones new drest with chissel and hammer; and every time the stone is taken up, there must be some tallow put round the spindle upon the bush, which will soon be melted by the heat the spindle acquires from its turning and rubbing against the bush, and so will get in betwixt them; otherwise the bush would take fire very soon.

The bush must embrace the spindle quite close, to prevent any shake in the motion, which would make some parts of the stones grate and fire against each other: whilst the other parts of them would be too far asunder, and by that means spoil the meal. Whenever the spindle wears the bush, so as to begin to shake in it, the stone must be taken up, and a chissel driven into several parts of the bush; and when it is taken out, wooden wedges must be forced into the holes; by which means the bush will be made to embrace the spindle again, close all round. In doing this, great care must be taken to drive equal wedges into the bush on opposite sides of the spindle; otherwise it will be thrown out of the perpendicular, and so hinder the upper stone from being set parallel to the under one, which is absolutely necessary for making good work. When any accident of this kind happens, the perpendicular position of the spindle must be restored by adjusting the bridge-tree with proper wedges between the brayer and it.

It frequently occurs, that the rynd is a little wrenched in laying down the upper stone upon it, or is made to sink a little lower on one side of the spindle than on the other; and this will cause one edge of the upper stone to drag all round upon the other, while the opposite edge will not touch. But this is easily set to rights, by raising the stone a little with a lever, and putting bits of paper, cards, or thin chips, between the rynd and the stone.

A less quantity of water will turn an overshot-mill (where the wheel has buckets instead of float-boards) than a breast-mill, where the fall of water seldom exceeds half the height of the wheel; so that, where there is but a small quantity of water, and a fall great enough for the wheel to lie under it, the bucket, or over-shot wheel, is always used: but where there is a large body of water with a little fall, the breast, or float-board wheel, must be used. Where the water runs only upon a small declivity, it can act but slowly upon the under part of the wheel; in which case, the motion of the wheel will be slow; and therefore the floats ought to be very long, though not high, that a large body of water may act upon them; so that what is wanting in velocity may be made up in power; and then the cog-wheel may have a greater number of cogs, in proportion to the rounds in the trundle, in order to give the mill-stone a sufficient degree of velocity.

It was the opinion of Smeaton, that the powers necessary to produce the same effect on an undershot-wheel, a breast-wheel, and an overshot-wheel, must be to each other as the numbers 2.4, 1.75, and 1.

Practical Rules for the Construction of Mills.

395. Measure the perpendicular height of the fall of water, in feet, above that part of the wheel on which the water begins to act, and call that the height of the fall.

Multiply this constant number 64.2882 by the height of the fall in feet, and the square root of the product will be the velocity of the water at the bottom of the fall, or the number of feet that the water there moves per second.

Divide the velocity of the water by three, and the quotient will be the velocity of the float-boards of the wheel, or the number of feet they must each go through in a second, when the water acts upon them so as to have the greatest power to turn the mill.

Divide the circumference of the wheel in feet by the velocity of its floats in feet per second, and the quotient will be the number of seconds in which the wheel turns round.

By this last number of seconds divide 60, and the quotient will be the number of turns of the wheel in a minute.

Divide 120 (the number of revolutions a mill-stone four feet and a half diameter ought to have in a minute) by the number of turns of the wheel in a minute, and the quotient will be the number of turns the mill-stone ought to have for one turn of the wheel.

Then, as the number of turns of the wheel in a minute is to the number of turns of the mill-stone in a minute, so must the number of staves in the trundle be to the number of cogs in the wheel, in the nearest whole numbers that can be found.

Of Clock-Work.

396. The technical terms, or terms of art, and the names of the various parts of a clock and watch will give a popular idea of the construction of either; and if you open your watch the following parts may be understood from description.

The wheels, and the rest of the work, are contained in the frame, which consists of the pillars and plates.

That which the main-spring lies in, is the spring-box: that which the spring winds about, in the middle of the spring-box, is the spring-arbor; to which the spring is hooked at one end. At the top of the spring-arbor, is the endless screw, and its wheel: but in spring clocks, it is a ratchet-wheel, with its click that stops it.

That which the main-spring draws, and about which the chain or string is wound, and which is commonly taper, is the fusee. In larger work, going with weights, where it is cylindrical, it is called the barrel; the small teeth at the bottom of the fusee, or barrel, that stop it in winding up, is the ratchet. That which stops it when wound up, and is for that end driven up by the string, is the gardecut.

The parts of a wheel are, the hoop, or rim; the teeth; the cross; and the collet, or piece of brass, soldered on the arbor, or spindle, on which the wheel is riveted.

A pinion is that little wheel which plays in the teeth of the wheel; its teeth (which are commonly few in number) are called leaves, not teeth.

The ends of the spindle are called pivots; the holes in which they run, pivot holes.

The guttered wheel, with iron spikes at the bottom, in which the line of ordinary thirty-hour house clocks runs is called the pulley.

The dial-plate, the hands, screws, wedges, stops, &c. hardly need mentioning.

Thus much for general names, which are common to all parts of a movement.

Watches are all such movements as shew the parts of time; and clocks are such as publish it by striking on a bell, &c. But commonly, the name of watches is appropriated to such as are carried in the pocket; and that of clock to the larger movements, whether they strike the hour or not. Watches which strike the hour, are called pocket-clocks, or more commonly repeating-watches.

The parts of a movement to be considered, are the watch and clock parts. The watch part of a movement is that which serves to measure the hours; in which the first thing to be noticed is the balance, whose parts are the rim, which is the circular part of it; the verge is its spindle, to which belong the two pallets, or leaves, which play in the teeth of the crown-wheel: in pocket-watches, that strong stud in which the lower pivot of the verge plays, and in the middle of which one pivot of the balance-wheel plays, is called the pottance. The bottom of this is called the foot; the middle part (in which the pivot of the balance-wheel turns) is called the nose; the upper part, the shoulder of the pottance. The piece which covers the balance, and in which the upper pivot of the balance plays, is the cock. The small spring in pocket watches underneath the balance, is the regulator, or pendulum spring.

The parts of a pendulum are the verge, pallets, and cocks, as before. The ball in long pendulums, the bob in short ones, is the weight at the bottom, which is fixed to the wire or rod. The term peculiar to the royal swing, are the pads, and there are, besides these, several other terms which clock-makers use in various sorts of pieces, as the snail or step-wheel in repeating clocks, the rack, the safe-guards, the several levers, lifters, and detents: but it would be tedious, nor is it necessary, to mention the particulars.

Of Pendulums.

397. A Pendulum is a heavy body hanging by a string or wire, moveable on a centre, and each swing is called a vibration, or oscillation. The vibrations are produced by the falling of the weight to the lowest part of the circle, and by the force acquired by the fall.

Galileo was the first who observed that all the vibrations of the same pendulum, whether great or small, are performed nearly in equal times: and the longer a pendulum, the slower are its vibrations, the squares of the times being inversely as the lengths.

Heat expands, and consequently lengthens, pendulums; and cold contracts, and shortens them. A pendulum, to vibrate seconds, must be shorter at the equator than at the poles.

Methods have been used for correcting the irregularity arising from expansion and contraction; one of these is the *gridiron*-pendulum. *Deal* is the best substance for pendulum-rods, as it is very little affected by heat and cold.

Of Wheel-Carriages.

398. The wheels of carriages turn round, on account of the friction they sustain in contact with the roads; and large wheels are more advantageous than small ones.

In four-wheeled carriages, the fore-wheels are made smaller than the hind ones, for the conveniency of turning; otherwise they would be better of the same size. Broad wheels are better for heavy carriages—such as waggons—because they press and harden, instead of cutting up the roads, as small wheels do.

The Steam-Engine.

399. The steam-engine, one of the noblest monuments of human ingenuity, was originally invented by the Marquis of Worcester, in the reign

of Charles II. And various persons improved on the Marquis's idea, till 1762, when the late Mr. Watt began to turn his attention to this machine, which he brought to perfection.

In the old engines, where the working stroke was only downwards, the piston-rod was attached to the beam by chains, which bent round an arch on the end of the beam, to make the piston-rod move in a perpendicular direction. In Watt's engines, where the working-stroke is doubled, that is, both upwards and downwards, chains could not answer this purpose, as, when the piston was forced upwards, they would slacken, and would not communicate the motion to the beam. It was necessary, therefore, that the piston-rod should be fastened to the beam with inflexible bars; but that the stroke might be perpendicular, a contrivance, called the parallel-joint was invented, which answers the intended purpose. In order to make the engine itself open and shut the steam and eduction-valves, long levers are attached to them, moved by the piston-rod of the air-pump. This part of the apparatus is called the working-geer, and is so contrived, that the valves may be worked either by hand or by the perpendicular rod. By shutting these valves, the engine may be stopped in an instant.

To communicate a rotatory motion to any machinery by the motion of the beam of the steam-engine, Watt made use of a large fly-wheel; on the axis of which, is a small concentric-toothed wheel. A similar toothed-wheel, is fastened by straps to a rod coming from the end of the beam, so that it cannot turn round on its axis, but must rise and fall with the motion of the great beam.

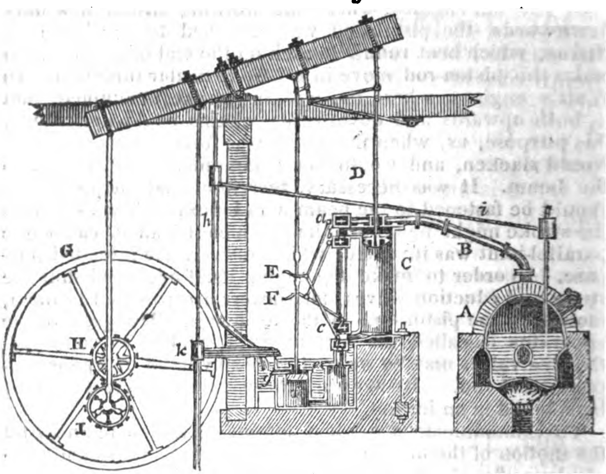
A bar of iron connects the centres of these two small-toothed-wheels, so that they cannot quit each other. This mode of moving the fly, is preferable to a crank; as it goes with twice the velocity; it is called the sun and planet wheel, from the resemblance of the motion to that of those luminaries. The mode of operation in Mr. Watt's engine, will be best understood by inspecting one of them at work.

The actual performance of some of these engines, as they have been ascertained by experience, is as follows:

An engine, having a cylinder of 31 inches in diameter, and making 17 double strokes per minute, performs the work of 40 horses, working night and day (for which three relays, or 120 horses must be kept), and burns 11,000 pounds weight of Staffordshire coal per day. A cylinder of 19 inches making 25 strokes, of 4 feet each, per minute, performs the work o

12 horses working constantly, and burns 3,700 pounds per day. A cylinder of 24 inches, making 22 strokes of 5 feet, burns 5,500 pounds of coals and is equivalent to the work of 20 horses.

400. *Watt's Steam-Engine at Work.*



Illus. A is the boiler, to which Mr. Watt has paid very great attention. It is generally of an oblong form; and the flame, after striking on its concave bottom, circulates round the sides, and sometimes returns in a pipe through the body of the water, before it is suffered to go up into the chimney. In his engines there are commonly two of these boilers, so that one of them may work while the other is repairing. B is the steam pipe which conveys the steam to the cylinder C, which is cased, and closed at top by a plate, having a collar of leather, through which the piston-rod D works. *a* and *c* are the steam-valves, through which the steam enters into the cylinder: it is admitted through *a*, when it is to press the piston downwards, and through *c* when it presses it upwards. *b* and *d* are the eduction valves, through which the steam passes from the cylinder into the condenser *e*, which is a separate vessel placed in a cistern of cold water, and which has a jet of cold water, continually playing up in the inside of it: *f* is the air-pump, which extracts the air and water from the condenser. It is worked by the great beam or leaver, and the water brought by it from the condenser, after being brought into the hot-well *g*, is pumped up again by the pump *h*, and is brought back again into the boiler by the pipe *i*: *k* is another pump, also worked by the engine itself, which supplies the cistern in which the condenser is placed, with cold water.

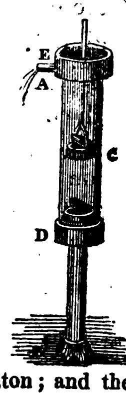
Of Pumps.

401. The pump is a common and most useful engine, first invented by Ctesibius, a mathematician of Alexandria, about 120 years B. C. When the pressure of the air came afterwards to be known, it was improved; and it is now brought to great perfection.

Of this machine there are three kinds, the *sucking*, the *lifting*, and the *forcing pump*.

By the two last, water may be raised to any height, with an adequate apparatus and sufficient power; by the sucking pump, it can only be raised thirty-three feet above the surface of the water. In practice, however, this kind of pump is seldom applied to raise water much above twenty-eight feet; because the air is sometimes lighter than thirty-three feet of water; and whenever that is the case, the pump will fail to act.

402. The *sucking-pump* is an engine both pneumatic and hydraulic:



Consisting of a pipe A B, open at both ends, in which is a moveable cylinder or piston C, as big as the bore of the pipe in that part wherein it works; and contrived by leathers or other means to fit the bore exactly, so as not to allow any air to pass between it and the sides of the pipe where it acts. In the piston there is a valve opening upwards, like a trap-door, to allow the air and water readily to ascend, but to prevent either of them from descending. This piston is called the bucket. It is moved up and down in the pipe by a rod fastened to a handle or lever, or such parts of machinery as are to work it. The pipe usually consists of two parts, of which the first and wider part A D, is called the working-barrel, because it contains the piston; and the other D B, the suction-pipe.

At the joining of the working barrel with the suction-pipe, there is a fixed valve D, opening also upwards. The lower end of the suction-pipe is immersed in water, and admitted into it through small holes at B, to prevent the entrance of dirt; at the top of the working-barrel is a wide head, and a pipe E, for the delivery of the water that is raised.

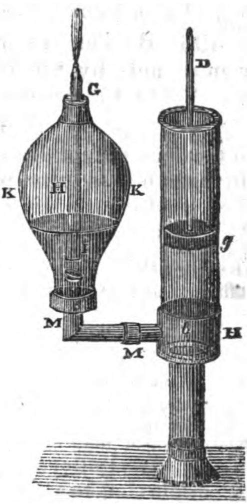
The water we admit is raised from the well by the *pressure of the atmosphere*. At the beginning of the operation, if the leathers be dry, the piston C, will not exhaust the air sufficiently, and the water will not rise; if a little water be poured upon the piston, it will swell the leathers and causing them to fit close, the piston will act. This is vulgarly called, *fetching* the water. The perpendicular height of the piston or bucket from the surface of the water in the well, must always be less than thirty-three feet, else the water will never get above the bucket. But when the height is less, the pressure of the atmosphere will be greater than the weight of the water in the pump, and will raise it above the bucket; and when the water has once got above the bucket, it may be lifted to any height, if the piston-rod be long enough, and a sufficient degree of strength employed.

403. In the *lifting pump* there is always a column of water lifted, whose base is equal to the top of the piston, and whose height is equal to the distance from the piston to the head. This weight will not be made less by diminishing the diameter of the barrel above the piston, because fluids press in proportion to their bases and perpendicular altitudes. This pump is much used in great water-works; it is the simplest of all in its operation, and produces an influx by the spout nearly equable.

404. The *forcing-pump*, consists of a barrel, and a piston or forcer, together with a *main* or lateral pipe to deliver the water, and in which there is a valve. The great end of the forcing pump is to convey the water further from its bed than either the sucking or lifting pump; and this it does more easily, by means of the lateral pipe and valve.

Thus, when the piston or plunger G is lifted up by the rod D, the water forces up the valve *b* in the box H, and rises into the body or barrel of the pump above H. When the piston G, therefore, (which we must observe has no hole or valve in it) is depressed to H, the valve *b* being closed by this action; the water in the barrel of the pump finding no other vent is forced into the pipe MM, and so up through the pipe. If there is no occasion for a continued stream of water, the pipe M is continued to any given height, and then the water would be thrown out like a *jet d'eaux* at every stroke of the piston.

But to make a continued stream, a further contrivance is necessary, and the air vessel KK has been annexed to the pipe M, to receive the water forced into it by each stroke of the piston. When, therefore, the water by this action continued, gets above the lower end of the pipe GHI, which is fixed air, tight in the top of the vessel, the air in the upper part is proportionably condensed. The action of the pump being then continued, in proportion as the vessel KK is filled with water, the air above is compressed, and in return presses in the surface of the water, and drives it out through the pipe at the orifice G in its end in a continued stream, and with great force.



The fire engine is nothing more than two of these pumps in action, to produce one continued stream.

405. The *chain pump* consists of two square, or cylindrical barrels, through which a chain passes, having a great number of flat pistons, or valves, fixed upon it at proper distances.

This chain passes round a kind of wheel-work, fixed at one end of the machine. The teeth of this are so contrived as to receive one half of the flat pistons, which go free of the sides of the barrel by near a quarter of an inch, and let them fold in, and they take hold of the links as they rise. A whole row of the pistons, which go free of the sides of the barrel by near a quarter of an inch, are always lifting when the pump is at work, and as this machine is generally worked with briskness, they bring up a full bore of water in the pump. It is wrought either by one or two handles, according to the labour required.

The preference which has been given to chain-pumps, over those which work by the pressure of the atmosphere, must have arisen from this circumstance, that the former have been found less liable to choke.

In point of friction, of coolness, and of cheapness, the sucking-pump has so evidently the advantage over the chain-pump, that it will not fail to gain the preference, when it shall be no longer liable to be choaked with gravel, &c. &c.

406. Buchanan's pump, which, like the common pump, acts by the pressure of the atmosphere, is not liable to the defects incident to other pumps upon that principle, being essentially different from those in general use. The principal object of its invention was to remove the imperfection of choaking, and in attaining this end, collateral advantages have also been produced, which enhance its utility. The points in which it differs from the common pump, and by which it excels, are, that it discharges the water below the piston, and has its valves lying near each other.

The advantages of this arrangement are, 1st, that the sand which may be in the water, is discharged without injuring the barrel or the piston-leathers; so that besides avoiding unnecessary tear and wear, the power of the pump is preserved, and it is not apt to be diminished or destroyed in moments of danger, as is often the case with the common and chain-pumps; that the valves are not confined to any particular dimensions, but may be made capable of discharging every thing that can rise in the suction-piece, without danger of being choaked; 2dly, if, upon any occasion, there should happen to be an obstruction in the valves, they are both within the reach of a person's hand, and may be cleared at once, without the disjunction of any part of the pump; and, 3dly, the pump is rendered capable of being instantaneously converted into an engine for extinguishing fire. Besides, it occupies very little space in the hold of a ship, and thus saves room for stowage.

Mr. Buchanan invented this pump when superintending the cotton mills at Rothsay; and though then a very little boy, I accompanied my father to see the first exhibition of this useful engine; indeed, I have every reason to believe that Mr. Buchanan consulted my father in this invention.

But this pump is not confined to nautical uses alone; its adaption extends to the raising of water in all situations, and with peculiar advantage where it happens to be mixed with sand or substances which destroy other pumps, as, for instance, in alum-works, in mines, in quarries, in the clearing of foundations; and, in its double capacity, it may be very conveniently used in gardens, bleaching-grounds, in stable and farm-yards, and in all manufactories, or other places, where there is a necessity for raising water, and the risk of fire.

With all these advantages, it is a simple and durable pump, and may be made either of metal or wood, at a moderate expense.

The Diving Bell.

407. To illustrate the principle of this machine, take a glass tumbler, plunge it into water with the mouth downwards; you will find that very little water will rise into the tumbler; which will be evident, if you lay a piece of cork upon the surface of the water, and put the tumbler over it; for you will see, that though the cork should be carried far below the surface of the water, yet that its upper side is not wetted; the air which was in the tumbler having prevented the entrance of the water; but as air is compressible, it could not entirely exclude the water, which, by its pressure, condensed the air a little.

The first diving-bell of any note, was made by Dr. Halley. It is most commonly made in the form of a truncated cone, the smallest end being closed and the larger one open. It is weighted with lead, and so suspended that it may sink full of air, with its open base downwards, and as near as may be parallel to the horizon, so as to close with the surface of the water. Mr. Smeaton's diving bell was a square chest of cast iron, four feet and a half in height, four feet and a half in length, and three feet wide, and afforded room for two men to work in it. It was supplied with fresh air by a forcing-pump. This was used with great success at Ramsgate. Other contrivances have been used for diving to small depths, which have answered very well, such as strong cases for the body, to keep off the pressure of the water, which were supplied with fresh air by pipes from the surface. A very good one of this kind is particularly described in the Philosophical Magazine, vol. viii. p. 59.

But the common shape of bells seems best calculated for any instrument of this name, to sustain the pressure of the surrounding fluid.

Invention of Balloons, and Progress of Aerostation.

408. Two brothers, of the names of Stephen and John Montgolfier, and proprietors of a paper manufactory at Annonay in France, formed the idea, in 1782, of causing a cloud of smoke to ascend in a bag. This experiment succeeding, it was repeated in November following, at Avignon, upon rather a larger scale; the brothers, on this occasion, using a silken bag. Burning paper being applied to the lower aperture the air was rarefied, and the bag ascended in the atmosphere, and struck rapidly against the ceiling. In the open air the bag rose to the height of seventy feet.

Encouraged by these experiments, they constructed a bag which contained about six hundred and fifty cubic feet of smoke. This broke the cords which held it, and rose to the height of about six hundred feet. Another bag one hundred and twenty feet in circumference, rose about one thousand feet and fell to the ground about three quarters of a mile from the place of its ascension.

A public exhibition now took place at Annonay, on the 5th June, 1783, when a linen bag lined with paper, containing upwards of twenty-three thousand cubic feet, and capable of raising five hundred pounds, ascended in ten minutes to the height of six thousand feet, and fell at the distance of seven thousand six hundred and sixty-eight feet from the place from whence it had set out. This balloon had been inflated with the smoke arising from burnt straw and wool.

One of the Montgolfiers being invited by the Academy of Sciences, to exhibit these experiments at their expence in Paris, he constructed a large balloon of an elliptical form, which lifted up eight persons who held it, and would have carried them all off, if more had not come to their assistance. Next day this experiment was repeated in presence of the members of the academy, the machine being filled by the combustion of fifty pounds of straw, made up in small bundles, upon which about twelve pounds of chapped wool were thrown at intervals. This balloon had ballast attached to it, weighing five hundred pounds, which it sustained in the air.

An immense balloon sixty feet high and one hundred and thirty feet in circumference was now prepared: it was beautifully decorated within and without. To this machine was attached a wicker cage, containing a sheep, a cock, and a duck, which were the first animals ever sent upon an aerial voyage. This experiment was not completely successful, on account of a sudden gust of wind which tore the cloth in two places near the top, before it ascended; however, it rose to the height of one thousand four hundred and forty feet, and after remaining in the air about eight minutes, fell to the ground, at the distance of ten thousand two hundred feet from the place, whence it set out. The animals were alive and well when they were taken out of the cage.

A new machine, one hundred and forty-five feet in circumference, and seventy-four feet high, being constructed, a grate and gallery were attached for the convenience of a man, who should have the power of keeping the balloon inflated by throwing straw upon the fire, and thus sustain himself in the atmosphere as long as he thought proper. This balloon was of an oval shape, and was elegantly painted on the outside with the twelve signs of the zodiac, &c. &c. the total weight, including the grate and other apparatus, being one thousand six hundred pounds. The first human being who was bold enough to ascend into the regions of space was M. Pilatre de Rozier; he took his seat in the gallery of this machine on the 15th of October, 1783. His first ascent was to the height of eighty-four feet, where he kept the balloon afloat for the space of about four minutes and a half. On repeating the experiment soon after he rose to the height of two hundred and ten feet; and on another repetition he ascended two hundred and sixty-two feet; but on a gust of wind having blown the balloon over some large trees, M. Pilatre suddenly disengaged himself from so perilous a situation, by throwing some straw and chopped wool on the fire, which raised him at once to a sufficient height. On descending again, he raised himself by the same means. Soon after, he ascended with M. Girond de Vilette to the height of three hundred and thirty feet; hovering over Paris for about ten minutes, in sight of all the inhabitants, the balloon, all the time, keeping perfectly steady. On the 21st of November, 1783, M. Pilatre, and the Marquis D'Alandes, placed themselves in the gallery of a balloon, which was left at liberty to ascend into the air: that is, it was not connected with those on *terra firma*, by means of ropes, which was formerly the custom; for it had been found that the ropes had little power over the aerostatic machines: the power of causing them to ascend and descend being invested in those who were seated in them. This voyage lasted about twenty-five minutes, during which time, the aeronauts travelled about five miles. This adventure, however, was near proving fatal; for the Marquis observed several round holes made by the fire in the bottom of the machine, but its progress was speedily stopped by the presence of mind of the voyager, who applying a wet sponge to the parts, speedily extinguished it.

Balloons inflated with Hydrogen Gas.

409. The success which attended Montgolfier's experiments with balloons inflated with rarefied air, gave rise to the idea of substituting Hydrogen Gas, which is the lightest aeriform substance known.

The first aerostatic experiments with this gas were performed by Messrs Roberts and Charles, in a varnished lutestring balloon, or bag, about forty feet in circumference: but, (as in all occupations which are novel,) they found considerable difficulty in the inflation of it. When set at liberty, however, it was found to be thirty-five pounds lighter than an equal bulk of common air. It remained in the atmosphere only three quarters of an hour, during which time, it traversed a distance of fifteen miles. Its descent was supposed to be owing to a rupture of the silk.

A large balloon was now constructed of gores of silk varnished over with a solution of caoutchouc; and a net was spread over it which was attached to a hoop, to which was suspended a boat of basket-work covered with linen which was beautifully ornamented. This boat or car was eight feet long, four wide, and three and a half deep, and its weight was one hundred and thirty pounds. The weight of the whole apparatus, including the two adventurers, was six hundred and four pounds and a half. This balloon ascended at a quarter before two in the afternoon, on the 1st of December, 1783, and rose to the height of one thousand eight hundred feet. By occasionally throwing out ballast, the balloon was kept at nearly the same distance from the earth during the rest of the voyage. After continuing in the air for three quarters of an hour, the aeronauts alighted at the distance of twenty-seven miles from Paris, having suffered no inconvenience during the voyage.

After this, balloons underwent a variety of improvements in size, &c. and aeronauts were enabled to perform very long voyages. Among others oars were added to balloons, by means of which considerable motion was given to them. The Duke de Chartres, with three other persons, were very near losing their lives, in an attempt to perform a voyage with a large balloon containing inflammable air, but having a smaller one filled with atmospheric air enclosed in it. They were attacked by a whirlwind which damaged the balloon very seriously, so that they were forced to cut the cords of the internal one, which made it fall down upon the mouth of the external one, so as to prevent the escape of the hydrogen gas, which was now rarefied to such a degree, by the burning rays of the sun, as to seem every instant ready to burst its envelope. In this awful crisis, however, the duke had the presence of mind to tear two holes in the balloon, which immediately tore for the length of seven or eight feet. They now descended with great rapidity, and would have fallen into a lake, had they not hastily thrown out sixty pounds of ballast, which enabled them just to reach the water's edge.

Another scheme which proved fatal to its contrivers, was that of affixing a rarefied air balloon to another inflated with hydrogen gas. The unfortunate aeronauts, on this occasion, were M. Pilatre de Rozier, (the gentleman who was the first that ever ascended in a balloon,) and Mr. Romaine, They ascended without any appearance of danger, but had not been long in the atmosphere, when the inflammable air balloon was seen to swell very much from the heat beneath, at the same time that the aeronauts seemed very anxious to get down, and busied in pulling the valve, in order to facilitate the escape of as much hydrogen as possible. A short time after, the whole machine was on fire, at about three quarters of a mile from the earth. No explosion was heard; and the silk which composed the air balloon continued expanded, and seemed to resist the atmosphere for about a minute; after which it collapsed, and the remains of the apparatus descended along with the two unfortunate men, so rapidly, that both of them were killed. M. Pilatre seemed to have been dead before he came to the ground; but M. Romaine was alive when some persons came up to the place where he lay, though he expired immediately after.

In France et Meudon, there was an aerostatic institute, where youths were regularly trained, and balloons prepared to accompany the armies, in order to give intelligence of the manœuvres of the enemy. The system of aerostatic education at this seminary has not, however, transpired. The principal of this college was the celebrated and ingenious Conté.

As balloons have been known to travel at the rate of forty, fifty, and sixty miles an hour, they might, in addition to their extensive uses in meteorological and telegraphic pursuits, be very beneficially applied to the transmission of mails from one country, or part of a country, to another. It is needless to mention the voyages of Lunardi, Garnerin, &c. in England, it is sufficient to say that they have proved successful and satisfactory. We will merely remark, that Garnerin's invention of the parachute, which is like an immense umbrella, and which will open the instant it is cut from the balloon, is equally wonderful and meritorious with that of the balloon itself. If this instrument had been attached to De Rozier's balloon, we should not, perhaps, have to lament his melancholy death whilst in the promotion of science.

Aerial Voyage of Mr. Blanchard and Dr. Jefferies, across the Straits of Dover.

410. Of all the aerial voyages, which have ever been projected, or put in execution, the most daring was that of which we are about to give an account. This voyage took place on the 7th of January, 1785. The morning was clear and frosty, with a wind that was barely perceptible, at N.N.W.

At one o'clock the boat was pushed off from one of the cliffs. As the balloon, however, was barely sufficient to carry two, they were immediately obliged to throw out all their ballast, except three bags of ten pounds each: they now rose gently, but made very little way, having hardly any wind. The barometer, which on the cliff had been at 29.7 inches, was fallen to 27.3, and the weather proved fine and warm. They had now a most beautiful prospect of the southern coast of England, and were able to count thirty-seven villages upon it, After passing over several vessels, they found that the balloon, (within ten minutes of two o'clock,) was descending: upon which they threw out a sack and a half of ballast, but it still descended, and with greater velocity than before: they now threw out the remaining part of the ballast. This, too, proving ineffectual, they threw out a parcel of books, which made the balloon ascend, when they were about midway between France and England.

At a quarter past two, finding themselves again descending, they threw away the remainder of their books, and in ten minutes after, they had a most enchanting view of the French coast. Still, however, the balloon descended; and as they had now no more ballast, they were obliged to throw away their provisions, the wings of their boat, and every thing they could possibly spare. "We threw away (says Dr. Jefferies) our only bottle, which, in its descent, cast out a steam like smoke, with a rushing noise; and when it struck the water, we heard and felt the shock very perceptibly on our car and balloon." All this proving insufficient to stop the descent of the balloon, they next threw out their anchors and cords, and at last stripped off their clothes, fastening themselves to certain slings, and intending to cut off the boat as their last resource.

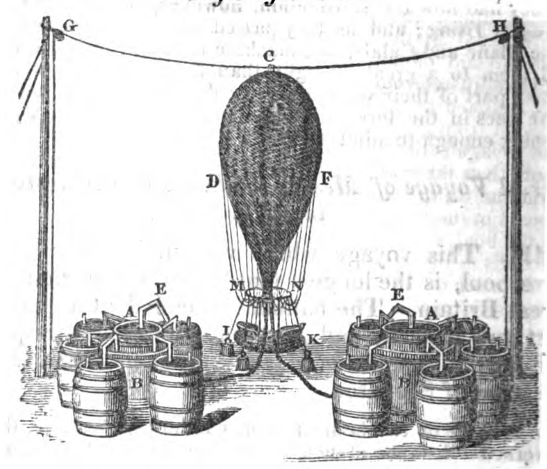
They had now the satisfaction, however, to find that they were fast rising; and as they passed over the highlands of Cape Blanc and Calais, the machine rose very fast, and carried them to a greater height than they had been at any former part of their voyage. They descended safely among some trees in the forest of Guiennes, where there was just opening enough to admit them.

Aerial Voyage of Messrs. Sadler and Livingstone, in 1819.

411. This voyage which was undertaken from Liverpool, is the longest that has ever been made in Great Britain. The balloon ascended at a quarter past two o'clock, and alighted at five minutes past five, at the distance of about a mile and a half from the town of Stockton.

In a space of two hours and fifty minutes, therefore, they traversed a distance of nearly one hundred and ten miles in a lineal direction; and if the undulations and aberrations of the machine are allowed for, it would make at least one hundred and seventy miles. In the course of this voyage, they traversed some of the finest parts of the counties of York and Durham, the views of which both gentlemen describe as sublime and enchanting beyond all description. At the height of nearly two miles from the earth, they took their refreshment, and drank the health of their sovereign, and prosperity to the town and trade of Liverpool. On approaching a town or village, they frequently descended so low as to be able to converse with the people. They did not suffer much from cold; the mercury in the thermometer generally ranging about 38. Unfortunately, they had no barometer with them; but Mr. Livingstone conjectures, that their utmost elevation might be about four miles and a quarter. Near the town of Stockton, they approached a range of hills; and on surmounting these, were somewhat startled at perceiving themselves within a few miles of the sea. They immediately drew the valve, and alighted with all possible expedition. The intrepid aeronauts undertook this long voyage with the view of trying the power of the balloon, and its capability of crossing the Irish Channel.

412. *The Method of filling Air Balloons with Hydrogen Gas.*



A A, are two tubs, three feet diameter and two feet deep, inverted in larger tubs; at the bottom of each of the inverted tubs there is a hole, to which is adapted a tin tube E, seven inches diameter, and eight inches long. To these tubes the silken tubes of the balloon are tied. Each of the tubs, B, is surrounded by several strong casks, so regulated in number and capacity, as to be less than half full when the materials are distributed. In the top of each of these casks are two holes; and to one of the holes is adapted a tin tube formed so as to pass over the edge of the tub, B, and through the water, and to terminate with its aperture under the inverted tub, A. The other hole, which serves for supplying the cask with materials, is stopped with a wooden plug.

These tin tubes may, however, be 3½ inches diameter, and the other holes in proportion.

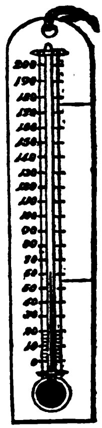
Two masts with a rope, &c. are used for this machine, although they are not absolutely necessary; because the balloon, by means of a narrow scaffold, or other contrivance, may be elevated five or six feet above the level of the tubs, A A. When the balloon is to be filled, the net is put over it, and suspended as exhibited in C D F; and having expelled all the common air from it, its silk tubes are fastened round the tin tubes E E, and the materials in the casks are properly proportioned, the iron being first put in, then the water, and lastly, the vitriolic acid. The balloon will soon be inflated by the inflammable air, and support itself without the aid of the rope G H. As the filling advances, the net is adjusted round it; the cords proceeding from the net are fastened to the hoop, N M; the boat, I K, is now suspended from the hoop, M N, and every thing necessary for the voyage is deposited in it. When the balloon is a little more than three quarters full, the silken tubes are separated from the tin tubes, and their extremities being tied, they are placed in the boat. Finally, when the aeronauts are seated in the boat, the lateral ropes are slipped off, and the machine ascends in the air.

In order to produce such a bulk of inflammable air as is necessary for a balloon of thirty feet in diameter, whose capacity is 14,137 cubic feet, there will be required 3,900 lbs. of iron turnings, 3,900 lbs. of vitriolic acid, and 19,500 lbs. of water; with which the balloon will not be above three-fourths full.

The Thermometer.

413. This instrument, used for measuring the degrees of heat or cold in any body, consists of a small ball blown at the end with a small glass tube of uniform width throughout. The ball, and part of the tube, are then filled with quicksilver, which has been previously boiled to expel the air. The end of the tube is then hermetically sealed.

The next object is to adapt to this tube a scale which shall indicate with truth the degrees of heat and cold. This is done in the following manner:



It is found by experiment that melting snow and freezing water are always of the same temperature. If, therefore, a thermometer be immersed, in the one or the other, the quicksilver will always stand at the same point. It has been observed, too, that water boils under the same pressure of the atmosphere, and the same temperature.

A thermometer, therefore, immersed in boiling water will uniformly stand at the same point.

Here then are two fixed points, from which a scale may be constructed, by dividing the intermediate space into equal parts, and carrying the same divisions above and below the two fixed points as may be thought necessary.

It is obvious, that all thermometers constructed on this principle may be compared together, for if they have been accurately made, and are placed in the same temperature, they will always point to the same degree on the scale.

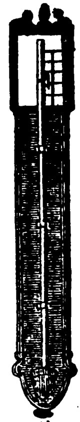
The freezing point on this thermometer, which is called Fahrenheit's, is fixed at 32°; the boiling is 212°; the intermediate space (212°—32°) 180° will at one point or other indicate all the degrees of heat between freezing cold and boiling heat; the former where water becomes ice, the latter where water becomes vapour.

The Barometer.

414. The invention and principle of this instrument are due to Torricelli, a pupil of Galileo.

The barometer was first applied to measure the height of mountains, by Pascal the celebrated Geometrician and Divine. For every 103 feet the barometer ascends, the mercury falls $\frac{1}{10}$ of an inch, 103 feet of air being equal to $\frac{1}{10}$ of an inch of mercury on the surface of the earth.

The barometer on the top of Snowdon in Wales, sinks 3.67 inches, therefore that mountain is 3720 feet in perpendicular height.



Barometers are of various kinds, and may be classed under the following heads; viz. the *common* or *straight barometer*, the *diagonal barometer*, the *horizontal* or *rectangular barometer*, and the *wheel barometer*.

A thermometer should always be attached to the barometer, and by the side of it a scale of correction, to show how much to add or subtract, from the height of the mercury, in the barometer, for the degree of temperature; for it is evident, that the mercury in the tube will be affected by heat and cold in the same manner as the thermometer, and, on that account, it will not shew the true weight of the atmosphere.

Besides the barometer, there are other instruments used for meteorological purposes, as the *thermometer*, *hydrometer*, *wind-gage*, *rain-gage*, *electrometer*, *&c.*

To be well enabled to prognosticate the change of weather, accurate observations ought to be made with all these instruments, aided by experience and knowledge of natural philosophy and chemistry; and even then, it requires more science than we are possessed of, to predict with certainty the alterations of the weather.

However, as the barometer is the most useful of these, and as it undoubtedly affords us considerable assistance, we shall lay down such directions as are most approved for this purpose.

1. The rising of the mercury presages, in general, fair weather; and its falling, foul weather; as rain, snow, high winds, and storms.

2. In very hot weather the falling of the mercury foretells thunder.

3. In winter, the rising presages frost; and in frosty weather, if the mercury fall three or four divisions, a thaw will certainly follow. But in a continued frost, if the mercury rise, it will certainly snow.

4. When foul weather happens soon after the falling of the mercury, expect but little of it; and, on the contrary, expect but little fair weather, when it proves fair shortly after the mercury has risen.

5. In foul weather, when the mercury rises much and high, and so continues for two or three days before the foul weather is quite over, then expect a continuance of fair weather to follow.

6. In fair weather, when the mercury falls much and low, and thus continues for two or three days before the rain

comes, then expect a great deal of wet, and probably high winds.

7. The unsetled motion of the mercury denotes uncertain and changeable weather.

8. You are not so strictly to observe the words engraved on the plates of the instrument (though in general it will agree with them), as the mercury's rising and falling: for if it stand at *much rain*, and then rise up to *changeable*, it presages fair weather; though not to continue so long as if the mercury had risen higher; and so, on the contrary, if the mercury stood at fair, and fell to *changeable* it presages foul weather; though not so much of it as if it had sunk lower.

From these observations it appears, that it is not so much the height of the mercury in the tube that indicates the weather, as the motion of it up and down: therefore, in order to form a right judgment of what weather may be expected, we ought to know, whether the mercury is actually rising or falling; and to this end the following rules are of use:

1. If the surface of the mercury be convex, standing higher in the middle of the tube than at the sides, it is generally a sign that the mercury is then rising. 2. If the surface be concave, it is then sinking. And, 3. If it be level, or rather, a little convex, the mercury is stationary.

Mercury, put into a glass tube, especially a small one, will naturally have its surface a little convex, because the particles of mercury attract one another more forcibly than they are attracted by glass.

If the glass be small, shake the tube, and if the air be grown heavier, the mercury will rise about half the tenth of an inch higher than it stood before; if it be grown lighter, it will sink as much. This proceeds from the mercury's sticking to the sides of the tube, which prevents the free motion of it until it be disengaged by the shock; and therefore, when an observation is to be made by such a tube, it ought always to be shaken first; for sometimes the mercury will not vary of its own accord, until the weather it ought to have indicated, be present.

The above-mentioned phenomena are peculiar to places lying a considerable distance from the equator; for in the torrid zone, the mercury in the barometer seldom either rises or falls much.

In Jamaica, it was observed by Sir William Beeston, that the mercury in the morning constantly stood at one degree below changeable, and at noon sunk to one degree above rain; so that the whole scale of variation there was only three-tenths of an inch. At St. Helena, too, where Dr. Halley made his observations, he found the mercury to remain almost stationary, whatever weather happened.

CHAPTER XVIII.

ACOUSTICS.

415. Acoustics signifies the doctrine of hearing, and the art of assisting that sense by means of speaking trumpets, hearing trumpets, whispering galleries, &c.

416. When bodies move in elastic fluids, they condense that part towards which they move, at the same time that the part they recede from is rarefied. This condensation or rarefaction must produce an undulatory or vibratory motion in the fluid.

If a body, by percussion or otherwise, be put into a tremulous motion, every vibration of the body will excite a wave in the air, which will proceed in all directions, so as to form a hollow sphere; and the quicker the vibrations of the body exceed each other, the less will be the distance between each successive wave. The sensation excited in the mind by means of these waves, which enter the ear, and produce a like motion in a thin membrane stretched obliquely across the auditory passage, is called *sound.*

That bodies move or tremble when they produce sound, requires no particular proof: it is evident in drums, bells, and other instruments, whose vibrations being large and strong, are therefore more perceptible; and it is equally clear, that a similar vibration is excited in the air, because this vibration is communicated through the air to other bodies that are adapted to vibrate in the same manner: thus bells, glasses, basons, and musical strings, will sound merely by the action propagated from other sounding bodies. Musicians well know that if a fiddle be played on by a good hand, and another fiddle be lying in the same room, the drawing of the bow over a particular string, will affect the similar string of the other fiddle.

417. It is established as well by mathematical reasoning, from the nature of an elastic fluid, whose compression is as the weight, as from experiment, that all sounds whatever, arrive at the ear in equal times, from sounding bodies equally distant. This common velocity is 1142 English feet in a second of time.

The knowledge of the velocity of sound, is of use in determining the distances of ships, or other objects: for instance, suppose a ship fires a gun, the sound of which is heard five seconds after the flash from the ignition of the powder is seen; then 1142 multiplied by 5, gives the distance 5710 feet, or an English mile and 330 feet. At New Gibraltar, when the watch-word of the night, *All's Well*, has been given by the centinel to the patrole on the ramparts, it has been heard distinctly, in a still, serene night, and the water perfectly smooth, at Old Gibraltar, a distance of about ten miles and a half.

418. When the aerial waves meet with an obstacle which is hard, and of a regular surface, they are reflected; and consequently, an ear placed in the course of these reflected waves, will perceive a sound similar to the original sound, but which will seem to proceed from a body situated in like position and distance behind the plane of reflection, as the real sounding body is before it. This reflected sound is called an *echo*.

Echoes are produced by the air which has been set in motion striking against a wall, rock, or such like, by which it is repelled. Echoes are familiar even to children, who fancy they hear the house talking to them. In this respect, the science of acoustics bears some analogy to that of optics: with this difference, however, that sound does not require a polished body to reflect it. That an echo may take place, the repelling object must be at least thirty feet distant.

Echoes are produced by mountains on the firing of guns. The famous echo in Woodstock Park returns seventeen syllables in the day-time, when the wind is brisk; and twenty in the night-time: for then the air being denser, the vibrations become slower, and a repetition of more syllables is heard. We are also assured, that there is a much finer echo from the north side of Stepney Church, in Sussex, which, in the night-time, will repeat these twenty-one syllables:—

Os homini sublime dedit, cœlumque tueri
Jussit, et erectos————

In the lake of Killarney, in Ireland, and in the subterraneous wonders of the Peaks of Derbyshire, echoes add much to the delight of the traveller.

"At two miles from Milan," says Addison, "there stands a building that would have been a master-piece of its kind had the architect designed it for an artificial echo. We discharged a pistol, and had the sound returned to us above fifty-six times, though the air was very foggy. There are two parallel walls which beat the sound back on each other till the adulation is quite worn out."

Some buildings have a remarkable property in conveying sound. In buildings of an elliptical shape a whisper in one focus will be distinctly heard in the other focus. The concert-rooms at Edinburgh are so contrived, that the performers sit in one focus, and the audience in the other. In the whispering gallery of St. Paul's, a person speaking in the lowest tone of voice, is distinctly heard at the opposite side. A person sitting in one of the recesses of Westminster bridge over the Thames, readily hears the sound of a person speaking in the opposite recess.

419. The waves of sound being thus reflexible, nearly the same in effect as the rays of light, may be deflected or magnified by much the same contrivances as are used in optics.

From this property of reflection, it happens that sounds uttered in one focus of an elliptical cavity, are heard much magnified in the other focus; instances of which are found in several domes and vaults, particularly the whispering-gallery of St. Paul's Cathedral, London, where a whisper uttered at one side of the dome is reflected to the other, and may be very distinctly heard. On this principle also are constructed the *speaking-trumpet* and the *hearing-trumpet*, which either are, or ought to be, hollow parabolic conoids, having a perforation at the vertex, to which the mouth is to be applied in speaking, and the ear in hearing.

420. But the principal use of this science is, in relation to *music,* to which it gives a basis on the certain principles of mathematics.

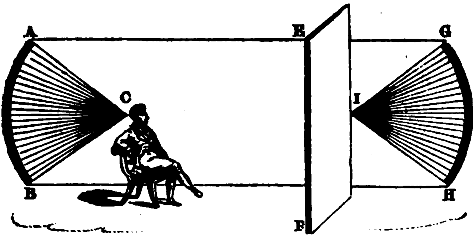
Thus, if a musical string, of any length, and a certain tenison, produce a certain tone, half that length, with the same tenison, will give the octave, two thirds of it the fifth, and the other notes of the scale in exact proportion. The varying of the sizes of *strings* will produce similar effects; or if strings of the *same* size be extended by different weights, the tones will become more acute, in ratio of the square roots of the weights.

421. Sound, in fact, is occasioned by the *vibrations* of bodies, such as musical chords, or pulses of air, which produce a certain degree of elasticity; and the perception of sound reaches the mind, when these vibrations are transmitted to the drum of the ear by the undulations of air, or of some of the gases. When sounds are considered in relation to their gravity or acuteness, or to the production of *melody,* or that union of melodies which constitutes *harmony,* the research evidently belongs to the science of *music.*

All sonorous bodies which vibrate an equal number of times in a second, yield the same sound. Thus, those which vibrate two hundred and fifty six times in a second, sound the note C in the middle of the musical scale. If the number of vibrations be half the above, or one hundred and twenty-eight, the note is an octave below the former; if the vibrations be double, or five hundred and twelve, the note will be an octave higher. A body which gives the gravest harmonic sound vibrates twelve times and a half in one second, and the shrillest sounding body vibrates fifty-one thousand one hundred times in a second. See our chapter on Music.

422. Many amusing experiments have been made in acoustics; even in the time of Cervantes the science of acoustics was studied, as may be judged from the exquisite description of Don Antonio's *oracular head,* to which we now give the name of the conversing statue.

The Conversing Statue.



423. Place a concave mirror, (made of tin or gilt pasteboard, and about two feet in diameter,) in a perpendicular direction, as A B in the foregoing figure. At the distance of five or six feet, let there be a partition, in which there is an opening E F, equal to the size of the mirror; and in this opening let a thin linen cloth, be placed, on which a picture is painted. This painting being in water colours, the sound will easily pass through.

Behind the partition, at the distance of two or three feet, place another mirror G H of the same size as the former; and let both be exactly opposite to each other. At the focus C *, of the mirror A B, let the ear of the figure of a man seated on a pedestal, be placed. The lower jaw of the figure must be made to open by a wire, and shut with a spring; and there must be another wire connected with the eyes, so as to give them motion and expression. These wires are to pass through the figure, under the floor, and be brought up behind the partition.

Let a person, properly instructed, be placed behind the partition, on the contrary side to where the statue is placed; and then propose to any person present, to put questions to the statue, by putting his mouth to its ear, and whispering softly; assuring the person that it will answer instantly. Now give a signal to the confederate behind the partition, who, by placing his ear in the focus I, of the mirror G H,

* The focus of each mirror is about the distance of from fifteen to eighteen inches.

will hear distinctly what the other said; and moving the eyes and jaws of the statue by the wires, will return an answer directly, which will in like manner be heard distinctly by the first speaker.

The statue may be made of wood, or plaster of Paris, and should be drest, as in the figure, in a man's habit. The mirrors may be fixed in the walls of a room at a proper distance from each other, and, in order to hide them from the view, they may be covered by a cambric handkerchief, as this thin covering does not in the least impede the sound.

CHAPTER XIX.

ALGEBRA.

424. ALGEBRA (Arabic, of uncertain derivation, but probably from *al* and *geber*, which signifies *the reduction of fractions to a whole number*) is a peculiar kind of arithmetic, for the solution of questions by means of numeral or literal equations.

The earliest treatise on algebra, which has come down to the present time, is that of Diophantus, of Alexandria, in Egypt, who flourished in the middle of the fourth century after Christ, and wrote a work on this subject in the Greek language, consisting originally of thirteen books, though, unfortunately for the interests of science, only the first six are now extant.

Other works on the subject, of a more easy and elementary kind, must, however, have existed long before the time of Diophantus, since he no where treats of the leading rules, as a writer in the infancy of the art would have done. Whether we are indebted for this admirable invention to the genius of the Greeks, as has hitherto been thought, or to that of some other ancient nation, cannot at this distance of time be easily ascertained; though from the information which for more than a century past has been gradually obtained through our intercourse with the East, there are strong reasons for believing that algebra, as well as our common system of arithmetic, originated among the Hindoos, or natives of India, who are known to possess some valuable works on the subject, containing rules and principles apparently not derived from any foreign source.

We are in possession of two celebrated works of Indian algebra, called the *Beja Ganita* and the *Lilavati*, the first of which treats wholly on algebra, and the latter on arithmetic, algebra, and mensuration, both written in the Sanscrit dialect and character, about the end of the twelfth, or beginning of the thirteenth century of the Christian era.

But, not to dwell upon this part of the subject, which, it must be confessed, is still attended with some obscurity, it is well known that, in whatever age or country algebra was first invented, both the name and the science was first made known to us, about the end of the eleventh century, by the Arabians, or Moors, who were settled in Spain. Algebra was introduced into Italy by Leonardus Bonacci, commonly called Leonard of Pisa, an Italian merchant, in the beginning of the thirteenth century: after this many manuscript treatises appeared in Italy; but the first printed works on this subject are those of Lucas Pacciolus, or Lucas de Burgos, in the years 1470, 1476, 1481, and 1494.

Hitherto the science had advanced no farther than quadratic equations; the passage indeed to the higher orders was a matter of considerable difficulty, for a general method for extracting their roots in species has not even yet been accomplished, nor in all probability will the value of the unknown quantity be ever generally expressed according to any given degree in algebraic formulæ, though those of numerical equations of every order may now be accurately found by the principles generally exhibited.

Soon after the publication of Lucas de Burgos, Scipio Ferreus, a professor of mathematics at Bologna, in Italy, first discovered, about the year 1505, a rule for resolving one of the cases of cubic equations; and, about thirty years afterwards, one of his disciples, of the name of Florido, to whom he had shown his method, having proposed several questions depending on this formula, to Nicholas Tartalea, by way of challenge, Tartalea not only discovered the rule for resolving them, but also those for some other cases.

Tartalea communicated his discovery to the celebrated Cardan, who published, in the year 1539, a very complete treatise on arithmetic and algebra, in nine books, in the Latin language, at Milan; and in a new edition of the same performance, printed in 1545, he gave a tenth book, containing the whole doctrine of equations, which had been chiefly revealed to him by Tartalea, under an oath of secrecy, about the time of the publication of the first nine books.

The resolution of certain cases of equations of the fourth order very soon followed that of equations of the third; a discovery for which we are indebted to Louis Ferrari, a young man of great talents, and one of the disciples of Cardan.

After the publication of Cardan's work, Tartalea also published a work on algebra; but it contained nothing remarkable, except his rules for the resolution of cubic equations.

About the same time that Cardan and Tartalea flourished in Italy, the science of algebra began to be cultivated in Germany; particularly by Stifel, who first employed the characters, $+$, $-$, $\surd$, for plus, minus, and root, as also the numerical indices, for powers as far as regards integral numbers. He likewise used the literal notation, A, B, C, D, for different unknown quantities.

A few years after the appearance of these in Italy and Germany, Robert Recorde proved by his writings, published at Cambridge, 1557, that algebra was not altogether unknown in England at that time.

Raphael Bombelli, of Bologna, who published a treatise on this subject in 1572, not only improved the notation, but the science itself.

A very ingenious treatise was published on arithmetic and algebra, in the Flemish dialect, in 1605, by Simon Steven, of Bruges, who greatly improved the notation of powers first given by Stifel for integral exponents and extended them also to fractional exponents.

But it is chiefly to the celebrated Vieta, whose algebraic works were written about the year 1600, though not printed till after his death, which happened in 1603, that we are indebted for having first generalized the algorithm of the science, and enriched it far beyond what his predecessors had done, by many new discoveries.

We have already mentioned that Stifel first introduced the capital letters for unknown quantities; but Vieta employed the same letters to denote all quantities, whether known or unknown: he was the first that introduced a general method for extracting their roots by a process similar to that of extracting the roots of pure powers; his method is commonly known by the name of the *Numeral Exegesis*.

Next after Vieta may be recorded Albert Girard, an ingenious mathematician of the Low Countries. Among the most distinguished analysts of this period, we may reckon our countryman, the celebrated Harriot, who, in his *Artis Analyticæ Praxis*, published by his friend Walter Warner, first introduced the use of the small letters, *a*, *b*, *c*, &c. of the alphabet, using the consonants for known, and the vowels for unknown quantities. He likewise farther shewed how the higher orders of equations may be produced by the continued multiplication of those of the first.

William Oughtred, another English mathematician, and contemporary with Harriot, also published, in the year 1631, a work on this subject, intitled *Clavis Geometrica.*

But no work, perhaps, has contributed more to the general advancement of this science than the geometry of Descartes. The celebrated Fermat was contempory with Descartes, and a competitor with him for some of his brightest discoveries; particularly the application of algebra to the doctrines of curves; and the method of resolving those problems known by the name of *Maximis et Minimis.*

Demoivre gave various papers in the *Philosophical Transactions,* containing a number of useful improvements and discoveries in algebra.

The inventions of Newton in the binomial theorem, in a general method of extracting the roots of equations, by approximation, in the reversion of series, &c. extended the science far beyond its former boundaries

We must not forget to mention that the labours of Halley, Raphson, Gregory, and Brook Taylor, who have also greatly contributed to its advancement.

The theory of series, in all its branches, has been cultivated with great success during the last two centuries, by John and James Bernoulli, Taylor, Demoivre, Nicole, Stirling, Euler, Lorgna, Simpson, Landen, Waring, and others, whose researches have greatly extended and improved this branch of analysis; but it was chiefly under the hands of Daniel Bernoulli and Euler that this doctrine was augmented and generalized.

Of late, Legendre has published a work of great ingenuity and research on the theory of numbers, containing a method of approximating towards the roots of equations by continued fractions.

We are likewise indebted to Arbogast for a very profound analytical work, intitled, *Du Calcul des Dérivations*, published in 1804; as also to Bezont and others.

To these we have likewise farther to add the two celebrated works of Lagrange, intitled, *Théorie des Fonctions Analytiques*, and *Leçons sur le Calcul des Fonctions*; as also his treatise, *De la Résolution des Equations Numériques*.

It only remains that we should mention some of the most useful elementary works for the use of beginners, which are those of Clairaut, Lacroix, Maclaurin, Simpson, Emerson, Wood, Bonnycastle, and Nicholson.

Arithmetic.

425. Arithmetic teaches the method of computing numbers, and explains their nature and peculiarities. The four first fundamental principles, viz. addition, subtraction, multiplication, and division have always, in a certain degree, been practised by different nations.

Numbers, as a science, must, in a great measure, have depended on the advancement of commerce, because arithmetical calculations, becoming then, more necessary, would receive a greater degree of attention. Thus arithmetic is, with great probability, supposed to have been of Tyrian or Phœnician invention. From Asia it is said to have passed into Egypt. From Egypt, arithmetic was transmitted to the Greeks; thence, with its improvements, it proceeded to the Romans, and from the Romans it has been dispersed over the modern nations of the world. The symbols or characters of numbers, and the scale of numerical calculations have been considerably diversified in different ages. The Hebrews and Greeks, and after them the Romans, had recourse to the letters of their alphabet for the representation of numbers. The Mexicans adopted circles for cyphers, and the ancient Peruvians coloured knotted cords, called *quipos.* The Indians, are, at this time, very expert in computing by means of their fingers; and the modern natives of Peru are said by the different arrangements of their grains of maize, to surpass Europeans, aided by all their rules.

The Arabian or Indian notation, which is now universally practised, was originally derived from the Indians and was, in the tenth century, brought by the Moors or Saracens from Arabia into Spain. Its improvements principally consist in its brevity and precision; instead of employing twenty-four characters, only nine digits and a cypher are wanted. The symbols also are more simple, more appropriate, and determined; and therefore the powers of them are less liable to inaccuracy or confusion. With the symbols too, the scale of numerical calculations has been varied. The first improvement was the introduction of reckoning by tens, which, no doubt, took its rise from the obvious mode of counting by the fingers, as that was customary in the primary calculation of every nation, except the Chinese

The Greeks had two methods of marking the advance of numbers; one on the plan which was afterwards adopted by the Romans, and which is still used to distinguish the chapters and sections of books; and in the other, the first nine letters of the alphabet represented the first numbers from 1 to 9, the next nine so many tens, from 10 to 90. The number of hundreds was expressed by other letters, supplying what was wanting either by other marks or characters, or by repeating the letters with different signs in order to describe thousands, tens of thousands, &c.

About the year of Christ 200, a new kind of arithmetic, called *sexagesimal,* was invented by Ptolemy. Every unit was supposed to be divided into 60 parts, and each of these into 60 others, &c. Thus from 1 to 59 were marked in the common way: then 60 was called a sexagesima, or first sexagesimal integer, and had one single dash over it, as 1′; 60 times 60 was called 'sexagesima secunda,' and marked 1″, &c. These methods of calculation are continued by astronomers in the subdivisions of the degrees of circles. The *decuple*, or Arabian scale, substitutes *decimal* instead of *sexagesimal* progression, and by this single process removes the difficulties and embarrassments of the preceding modes. Thus the signs of numbers, from 1 to 9, are considered as simple characters, denoting the simple numbers subjoined to the character; the cypher, 0, by filling the blanks, denotes the want of a number, or unit, in that place; and the addition of the columns in a ten-fold ratio, always expressing ten times the former, leads from tens, according to the order in which they stand, in a method at once most luminous and certain.

For decimal parts we are indebted to Regiomontanus, who, about the year 1464, published his book of '*Triangular Canons.*' Dr. Wallis invented the use of *circulating* decimals, and the arithmetic of *infinites;* but the last, and with regard to extensive application, the greatest improvement which the art of computation ever received, was from the invention of *logarithms,* the honour of which is due to John Napier, baron of Merchiston, in Scotland, who published his discovery about the beginning of the seventeenth century. Mr. Henry Briggs followed Baron Napier on the same subject. Arithmetic may now be considered as having advanced to a degree of perfection which, in former times, could scarcely have been conceived, and to be one of those few sciences which have left little room for further improvement.

Geometry.

426. Geometry treats of lines, surfaces, and solids, and is the doctrine of extension and magnitude in general. Hence a line, an angle, a circle, and, in short, figures of every size or shape, come under the subject of geometry. What has length and breadth only, is termed a superficies, such as the admeasurement of a board, a table, a field, or a country, to determine its contents, in feet, yards, acres, &c. What has length, breadth, and thickness, is termed a solid; and of whatever size or figure it may be, whether a log of wood, a pyramid, or a globe. Geometry is able to ascertain its number of cubic inches, yards, or miles. Geometry, or the art of measuring, like all other useful inventions, appears to have been the offspring of want and necessity; and to have had its origin in those remote ages of antiquity, which are far beyond the reach of credible and authentic history.

The use of geometry in most of the different branches of the mathematics is so general and extensive, that it may be justly considered as the parent of all the rest, and the source whence are derived the various properties and principles to which they owe their existence. Artificers of almost all denominations, are indebted to this invention for the establishment of their several occupations, and the perfection and value of their workmanship. Without its assistance all the great and noble works of Art would have been imperfect and useless. Plato testified his conviction of the importance of geometry, by placing over the door of his academy, an inscription to this effect, "Let no one ignorant of geometry enter here."

END OF VOL I.

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