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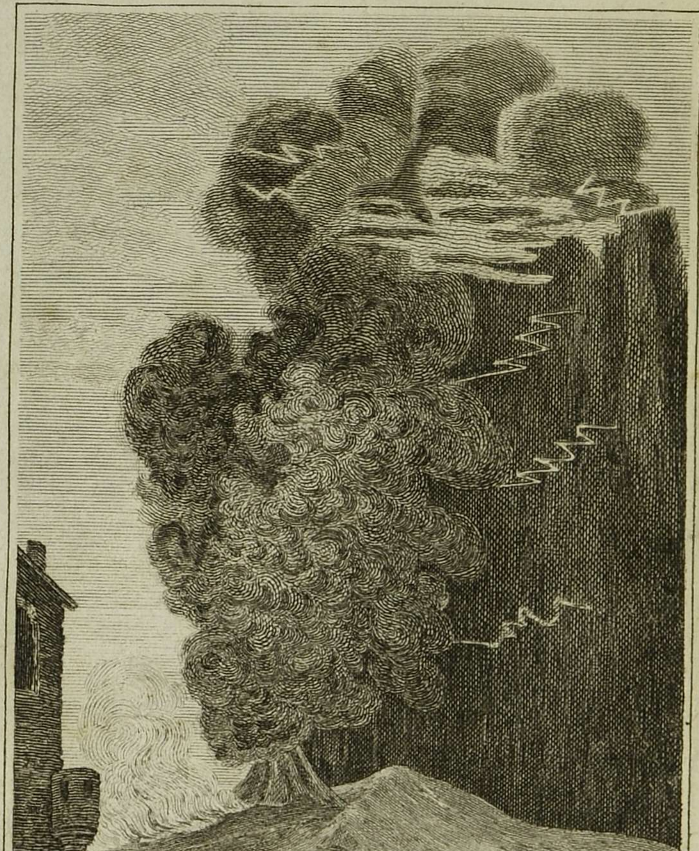
Joseph Here
A Reward for
Diligence & Good conduct
Melksham School
20th of 6 mo 1814


EDGAR OSBORNE
COLLECTANIA JUVENILIA

Frontifspiece to Telescopes Philofophy.



VIEW OF MOUNT VESUVIUS

see page 75.

THE NEWTONIAN SYSTEM

OF

PHILOSOPHY,

EXPLAINED BY FAMILIAR OBJECTS,

In an Entertaining Manner,

FOR THE USE OF YOUNG PERSONS.

BY TOM TELESCOPE, A.M.

Illustrated with Copperplates and Cuts.

A NEW IMPROVED EDITION,

With many Alterations and Additions, to explain the late new Philosophical Discoveries, &c. &c.

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Hearing

INTRODUCTION.

INTRODUCTION.

A PARTY of young people of both sexes being invited to spend the holidays with a friend in the country, were sometimes at a loss for amusement, especially when rainy weather confined them to the house. Several diversions were proposed: some named shuttle-cock; others, blind-man's buff; at length a game of cards was mentioned. On hearing this, Mrs. Mentor, the lady who had invited them, said, she hoped that they would think of some more innocent amusement. Playing at cards for money, says she, is so nearly allied to covetousness and cheating, that I abhor it; and have often wondered, when I was at Bath, to see people, whose age and rank required them to set a good example, so far mistake themselves and abandon common sense, as to lead a young gentleman, who had just changed his dress, or a little girl in a frock, up to a gaming-table, to play and bet for shillings, crowns, and perhaps guineas, among a circle of sharpers. Parents, continued she, might almost as well teach their children to thieve as to game: for they are kindred employments, and generally terminate in the ruin of both fortune and character.—As I have objected to the diversion you have proposed, it is but fair that I should provide another that is likely to afford more entertainment and novelty than the common sports of your age. There is a very ingenious young man, continued she, in this neighbourhood, who has studied natural philosophy, and is qualified to instruct and amuse us at the same time. He is of an amiable disposition, and takes pleasure in communicating, in the most familiar manner, the knowledge he has acquired by hard study; I will send for him, and desire he will bring such instruments as may be necessary to explain his lectures. A general smile of approbation showed that the proposal was agreeable. In less than an hour Mr. Thomas Telescope made his appearance, and with great modesty and easy politeness, complied with the wishes of the company, by opening his first lecture, which will be presented in the next chapter.

LECTURE I.

Of Matter and Motion.

By matter, my young friends, is meant the substance of all things, or that of which all bodies are composed, in whatever form or manner they may present themselves to our senses; for this top, that ivory ball, the hill before us, and all things you see, are equally made of matter, though differently formed.

The nature of motion requires no explanation; for every boy who can whip his top knows what motion is.

Matter, or body, may be either in motion, or at rest. As for example, when a boy whips a top, it turns round, or is in motion; but when he leaves off whipping, the top falls down, and is at rest.

When a body is in motion, as much force is required to make it rest, as was required, while it was at rest, to put it in motion. Thus: suppose a boy strikes a ball from a trap, and another stands close by to catch it, it will require as much strength or force to stop that ball, or put it in a state of rest, as the other gave to put it in

 motion;

motion; allowing for the distance the two boys stand apart.

No body or part of matter can give itself either motion or rest: and therefore a body at rest will remain so for ever, unless it be put in motion by some external cause; and a body in motion will move for ever, unless some external cause stops it.

This seemed so absurd to Master Wilson, that he burst into a loud laugh. What! says he, shall any body tell me that my hoop or my top will run for ever, when I know by daily experience, that they drop of themselves without being touched by any body? At this our philosopher smiled, and having requested silence, said, you judge without reflection, Master Wilson; if you intend to go through my course of philosophy, and to make yourself acquainted with the nature of things, you must prepare to hear what is more extraordinary than this. When you say that nothing touched the top or the hoop, you forget the friction or rubbing against the ground they run upon, and the resistance they meet with from the air in their course, which is very considerable, though it has escaped your notice. Somewhat too might be said on the gravity and attraction between the top, or the hoop, and the earth; but that you

you are not yet able to comprehend, and therefore we shall proceed in our lecture.

A body in motion will always move on in a straight line, unless it be turned out of it by some external cause. Thus, we see that a marble shot upon the ice, if the surface be very smooth, will continue its motion in a straight line till it is stopt by the friction of the ice and air, and the force of attraction and gravitation.

The swiftness of motion is measured by distance of place, and the length of time in which it is performed. Thus, if a cricket-ball and a fives-ball move each of them twenty yards in the same time, their motions are equally swift; but if the fives-ball moves two yards while the cricket-ball is moving one, then is the motion of the fives-ball twice as swift as the other.

But we must also consider the quantity of motion measured by its swiftness, as in the instances I have just given you, and the quantity of matter moved, at the same time. Thus, if the cricket-ball be equal in bulk and weight to the fives-ball, and move as swift, then it hath an equal quantity of motion. But if the cricket-ball be twice as big and heavy as the fives-ball, and yet moves equally swift, it hath double the quantity of motion; and so in proportion.

All bodies have a natural tendency, attraction, or gravitation towards each other. Here Tom Wilson, again laughing, told the company that philosophy was made up of nothing but hard words. It appears so to you, young gentleman, because you are too idle and giddy to enquire the meaning of terms of science; or when you have learnt them, to retain their signification, said our philosopher, a little ruffled at Tom Wilson's rudeness. All words, continued Mr. Telescope, are difficult till they are explained; and when that is done, we shall find that gravity or gravitation will be as easily understood as praise or commendation; and attraction as easily as correction, which ill manners always deserves, glancing his eye at Wilson.

Gravity, my young friends, is that universal disposition of matter which inclines or carries the lesser part towards the centre of the greater part, which is called weight or gravitation in the lesser body, but attraction in the greater, because it draws, as it were, the lesser body to it.—Thus, all bodies in or near the earth's surface have a tendency, or seeming inclination, to descend towards its middle part or centre; and but for this principle in nature, the earth (considering its form and situation in the universe) could not subsist as it is, for we all suppose the earth to be nearly round; (nay, we are sure it is so, for Captain Cook, and many other navigators, you know, have sailed round it; and as it is suspended in such a mighty void or space, and always in motion, what should hinder the stones, water, and other parts of matter falling from the surface, but the almighty arm of God, or this principle or universal law in nature, of attraction and gravitation, which he has established to keep the universe in order. To illustrate and explain what I have said, let us suppose the following figure to be the earth

and seas: let Tom Wilson stand at this point of the globe or earth where we are, and Harry Thomson at the opposite part of the earth, with his feet (as they must be) towards us: if Tom drop an orange out of his hand, it will fall down towards Harry: and if Harry drop an orange, it will fall seemingly upwards (if I may so express myself) towards Tom: and if these oranges had weight and power sufficient to displace the other particles of matter, of which the earth is composed, so as to make way to the centre, they would there unite together, and remain fixed: and they would then lose their power of gravitation, as being at the centre of gravity and unable to fall, and only retain in themselves the power of attraction.

This occasioned a general laugh; and Tom Wilson, starting up, asked how Master Thomson was to stand with his feet upwards, as here represented, without having any thing to support his head? Have patience, says the philosopher, and I will tell you: but pray behave civilly, Master Wilson, and don't laugh at every thing you cannot comprehend. This difficulty is solved, and all the seeming confusion which you apprehend of bodies flying off from each other is removed, by means of

this

this attraction and gravitation. Ask any of the sailors who have been round the world, and they will tell you that the people on the part of the globe over against us, do not walk upon their heads, though the earth is round; and though their feet are opposite to our's, they are in no more danger of falling into the mighty space beneath them, than we are of falling (or rather rising, I must call it here) up to the moon or the stars.

But besides this general law of attraction and gravitation, which affects all bodies equally and universally, there are particular bodies that attract and repel each other, as may be seen by this magnet or loadstone, which has the property of attracting or bringing iron to it with one end, and repelling or forcing it away with the other. My knife, says Sam Jones, which was rubbed on a loadstone some years ago, still retains the power of picking up needles and small pieces of iron.

But this, says Mr. Telescope, is but a small part of the virtues of the loadstone; for until its use was discovered, sailors never ventured with their ships out of sight of land. You certainly jest, Sir, says Harry Thomson, for it is impossible that a piece of iron like that, can be of any

service

service in navigating those large ships I saw some time ago. It betrays ignorance, said Mr. Telescope, to believe every thing impossible for which we cannot see a cause: but on the present occasion, I will soon remove your doubts, and show you the truth of my assertion. A piece of steel is first procured, made something like a needle, but flat, about four inches long; this is rubbed with the loadstone, and then balanced exactly on two points or pivots, so that it may turn round freely. One of the ends of the needle thus balanced, will always point towards the north. This needle, when fixed in a box, is called the mariner's compass; and with this guide, being always able to find the north, sailors can steer to any part of the world; which they could not do without the help of such a piece of iron.

When bodies are so attracted by each other as to be united or brought into close contact, they then adhere or cohere together, so as not to be easily separated: and this is called in philosophy, the power of cohesion, and is undoubtedly that principle which binds large bodies together; for all large bodies are made up of atoms or particles inconceivably small. And this cohesion will be always proportioned to the

number

number of particles or quantity of the surface of bodies that come into contact, or touch each other: for those bodies that are of a spherical form will not adhere so strongly as those that are flat or square, because they can only touch each other at a certain point; and this is the reason why the particles of water and quicksilver, which are globular or round, are so easily separated with a touch, while those of metals and some other bodies, are not to be parted but with great force. To give a familiar instance of this cohesion of matter, our philosopher took two leaden balls, and filing a part off each, so that the two flat parts might come into close contact, he gently pressed them together, and they united so firmly, that it required some considerable force to get them asunder.

The same force applied to two different bodies will always produce the same quantity of motion in each of them. This principle I proved some time ago by an easy experiment:—A boy was put into a boat on the Thames, by the Millbank, which, including his own weight, weighed ten hundred. Another boat of one hundred weight was placed just opposite, having a rope fastened to it; this rope was given to the boy in the first boat, who pulled it till

the

the two boats met: and we observed, that as the boats approached each other, the small boat moved ten feet for every foot the other moved: which confirms what I have before observed as to the quantity of motion.

Attraction is the stronger the nearer the attracting bodies are to each other; and in different distances of the same bodies it decreases as the squares of the distances between the centres of those bodies increase. By this expression I mean, the sum of a number multiplied by itself: sixteen, for example, is the square of four. But to return to our subject: If two bodies, at a given distance, attract each other with a certain force; at half the distance they will attract each other with four times that force.

LECTURE II.

Of the Universe, and particularly of the Solar System.

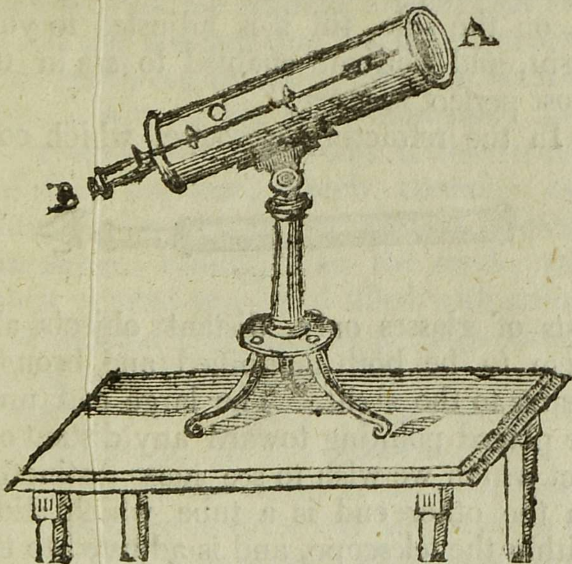
The young people were so well pleased with Mr. Telescope's instructions, that Mrs. Mentor determined to gratify them further, by obtaining permission to visit an observatory that was erected in the neighbourhood, in the form of a high tower, standing on an eminence, adapted to the examination of the heavenly bodies, and furnished with a variety of instruments necessary for astronomical and philosophical observations. The company having taken their seats, the philosopher addressed them in the following words:—

Look round, my dear friends, says he; you see the earth seems to be bounded at an equal distance from us every way, and appears to meet the sky which forms this beautiful arch or concave over our h ads. "The heavens declare the glory of God, and the firmament showeth his handy work," as the Psalmist beautifully expresses it. That distant round where we lose sight of the earth, is called the horizon; and when the sun, moon, and stars, emerge from beneath, and come into our sight, we say they are risen, or got above the horizon: for all this glorious canopy bespangled with lights, that bedeck the sky and illuminate the earth, as the sun, the fixed stars, the comets, and planets, (to which last our earth and moon belong,) have all apparent motion, as may be perceived by the naked eye; though, in fact, none move but the planets and comets; as will be proved hereafter.

But besides the stars which we see, there are others not discernible by the naked eye, some of which are fixed stars, and some are bodies moving about the most distant planets, which were invisible and unknown to us before the discovery of telescopes.

Pray

Pray hand me that reflecting telescope.



which having placed upon the table, he thus explained the different parts of it:—

This telescope, from its construction, magnifies more than any other kind. It contains, withinside, two metallic speculums, a large and a small one. These, with two glasses contained in the small tube, marked B, serve so to reflect and refract the rays of light issuing from the object, as to show them under a magnified appearance. In using the telescope, whilst

 your

your eye is looking through at B, and the end A, turned towards the object you wish to examine, you must turn the long screw C, on the side, till it is adjusted to your sight, and you are enabled to see in the most perfect manner.

In the refracting telescope, which con-

sists of glasses only, distant objects also seem to be both magnified and brought nearer to the sight. The large end must be placed pointing toward any distant object which we wish to see more distinctly. In the other end is a tube which slides within the telescope, and is adjusted to the proper distance by gently drawing it outwards. Now, if you look through the glass at the end of this tube, to that part of the heavens to which I have pointed it, or indeed any other part, you will perceive more stars than you saw before with your eye alone. These are fixed stars, and are called so, because they always keep the same distance from each other, and the same distance from the sun, which is also immovable; and were he placed at the immense distance they are at, would probably

bably appear no bigger than one of them. Hence some philosophers have concluded, and I think not without reason, that every fixed star is a sun that has a system of planets revolving round it, like our solar system. And if so, how immensely great, how wonderfully glorious is the structure of this universe, which contains many thousand worlds as large as ours, suspended in æther, rolling, like the earth, round their several suns, and filled with animals, plants, and minerals, all perhaps different from ours, but all intended to magnify the Almighty Architect; "who weighed the "mountains in his golden scales, who "measured the ocean in the hollow of his "hand, who drew out the heavens as a "curtain, who maketh the clouds his chariot, and walketh on the wings of the "wind."

The fervor and air of piety with which this was delivered, silenced every disposition to levity and ridicule; and impressed all present with sublime ideas of the majesty and omnipotence of the Creator. Master Wilson, who had before been very impertinent, began now to feel abashed, in the comparison of his own ignorance with the knowledge of one but a few years older; and as the solar system had been mentioned, ed, he requested that Mr. Telescope would explain it to him.

That I will with pleasure, replied the philosopher, if you will be kind enough to hand me that orrery that is in the corner of the observatory, and place it on the table; but first let me observe to you, that of these heavenly bodies some are luminous, and lend us their own light, as do the sun and fixed stars; while others are opaque, and have no light of their own to give us, but reflect to us a part of the light they receive from the sun. This is particularly the case with respect to the planets and comets of our solar system, which all give us a portion of the light they have received, and we, in return, reflect to them a portion of ours; for I make no doubt but those who inhabit the moon have as much of the sun's light reflected to them from our earth, as we have reflected to us from the moon.

The inhabitants of the moon! says Master Lovelace, with some emotion; whither will you lead us? What! are the stories that have been told of the Man in the Moon, then, true?

I do not know what stories you have heard, replied the philosopher; but it is no extravagant conjecture to suppose that

the

the moon is inhabited as well as the earth; though what sort of inhabitants they are, we on earth are unable to discover. When I consider the extent of the universe, with the multitude and variety of creatures that probably people it, I am lost in admiration of the goodness of God, who has dispensed enjoyment to so many millions of beings, adapted to their different natures. The sun, which gives life to the world, seems only a beam of the glory of God; and the air, which supports that life, is, as it were, the breath of his nostrils.

Do thou, O God, support me while I gaze with reverence at thy wonderful productions; since it is not idle, impertinent curiosity that leads me to this enquiry, but a fervent desire to see only the skirts of thy glory, that I may magnify thy power and thy mercy to mankind.

Of the Solar System.

The orrery is a machine contrived to illustrate the motions and relative situations of the planets that compose our solar system, which consists of a cluster of stars that perform their circuits around one that is fixed; this fixed luminous body is the sun, represented by the the ball *a*, in the middle.

Forgive my interruption, says Tom Wilson, but how is it then, that we daily see the sun rise and set?

Your question, replies Mr. Telescope, is very natural; for it was an opinion held by the ancients some thousand years, that the earth was the centre of the universe, and that the sun and planets revolved round it; but I think the inconsistency of this supposition is easily shown by a common occurrence in a kitchen: I mean the roasting a small bird on a spit before a large fire. Would not you think it very absurd, if the cook should endeavour to make the grate, with a large fire, move round the small bird on the spit?

Certainly I should, answers Tom Wilson, for it would be far better for the bird

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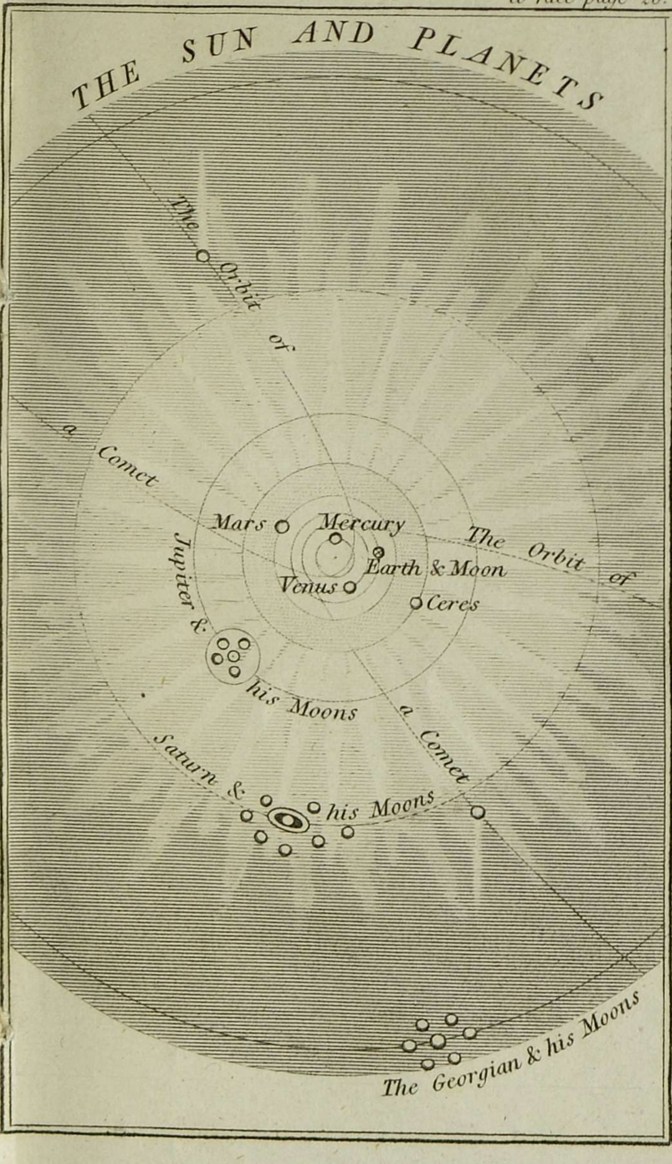

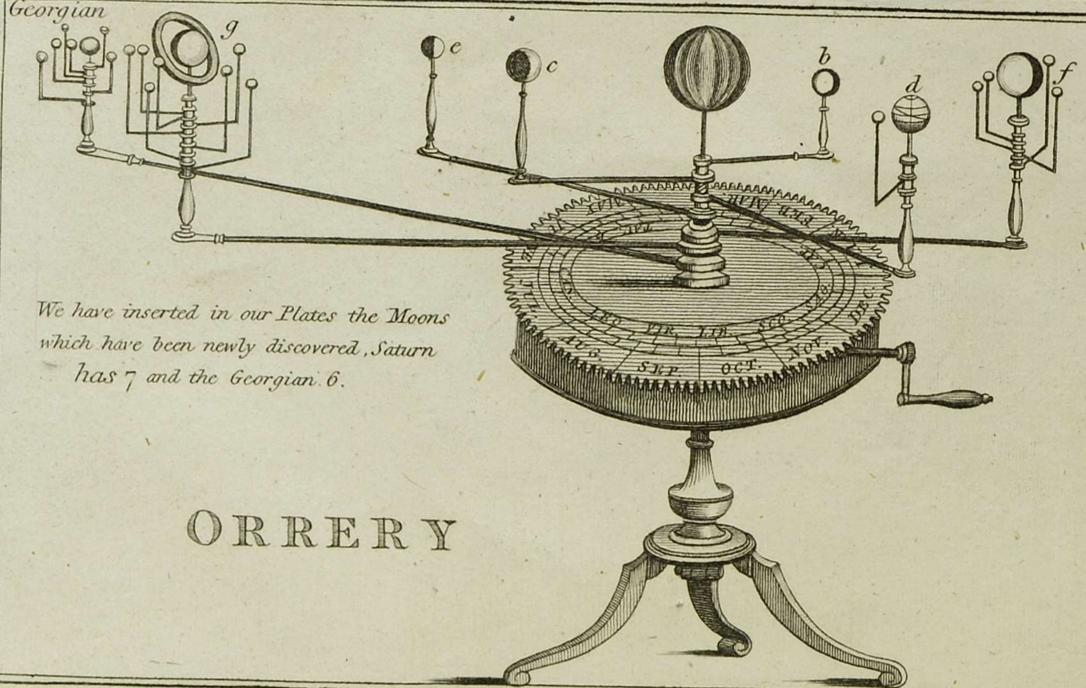

We have inserted in our Plates the Moons which have been newly discovered, Saturn has 7 and the Georgian 6.

ORRERY

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to turn round before the fire, than the fire to turn round the bird.

Very well, then, says our philosopher, the sun being more than a million times larger than our earth, we have good reason to believe that it is the centre of our system, and that the earth and other planets move round it. But you will understand this better if you look at the plate I have drawn of the sun and the planets, in their several orbits or circles, with their relative distances from the sun, and from each other; to which I have added the orbit of a comet.

The planets, as I have already observed, are bodies that appear like stars, but are opaque; that is, they have no light in themselves, but receive it from the sun and reflect it upon us. Of these there are two kinds: the one called primary, and the other secondary planets.

There are seven primary planets; and these are marked on the orrery as follows: Mercury *b*, Venus *c*, the earth *d*, Mars *e*, Jupiter *f*, Saturn *g*, and the Georgium Sidus or Herschel. The last of these was discovered only a few years since by Dr. Herschel, and called by him, out of respect to his present Majesty King George III.

the

the Georgium Sidus, or Georgian. All these move round the sun, as you see by my turning the winch of the orrery; whereas the secondary planets move round other planets. The moon, you know, (which is one of the secondary planets) moves round the earth; four moons, or satellites, as they are frequently called, move round Jupiter; five round Saturn; and only two have yet been discovered to move round the Georgian; though we have great reason to believe there are more; but from the prodigious distance of that planet, we have not yet perceived them. Thus has the Almighty provided light for those regions that lie at such an immense distance from the sun.

I have made out a table of the periods, distances, and diameters, of the several planets.

	Revolves round the sun in years, days.	Distance from the sun in Eng. Miles.	Diameter in Eng. miles.
Mercury	0 88	37,000,000	3261
Venus	0 224	68,000,000	7699
Earth	1	95,000,000	7920
Mars	1 & 322	145,000,000	5312
Jupiter	11 — 314	493,000,000	90255
Saturn	29 — 167	906,000,000	78012
Georgian	82 — 121	1812,000,000	35217

Several

Several small planetary bodies have been recently discovered, that, on account of their comparatively diminutive size, have been termed asteroids, which perform their revolutions between the orbits of Mars and Jupiter. It is probable that they will be distinguished by the names of the astronomers who discovered them: these are M. Piozzi, Dr. Olbers, and Mr. Harding. As few particulars of them are yet known, I have not inserted them in my table. These all move round the sun from west to east, in orbits rather inclining to an oval than a perfect circle, the reason of which will be explained hereafter.

The knowledge we have of comets is very imperfect; it is a general supposition that they are planetary bodies forming a part of our system, for they revolve about the sun in extremely long elliptic curves, being sometimes very near it, at others extending far beyond the sphere of the Georgian. The period in revolving about the sun, of one which appeared in 1680, is computed to be 575 years.

But let us quit these bodies, of which we know so little, and speak of our old companion the moon, with whom we ought to be better acquainted; since she not only lights us home in the night, but lends her aid

aid to get our ships out of the docks, and to bring in and carry out our merchandise; for without her assistance you would have no tides. But more of this on a future occasion.—A little more now, if you please, says Tom Wilson. What then, does the moon pour down water to occasion the tides? I am at a loss to understand you. No, replied our philosopher, the moon does not pour down water to occasion the tides: but she, by attracting the waters of the sea, raises them higher; and that is the reason why the tides are always governed by the moon.

The moon's diameter is 2160 miles; her distance from the earth is 240,000 miles. She moves round it in the same manner as the earth does round the sun; she performs her synodical motion, as it is called, in 29 days, 12 hours, and 44 minutes; though the periodical is 27 days, 7 hours, and 43 minutes. By this motion of the moon are occasioned the eclipses of the sun and moon; and the different appearances, aspects, or phases she at different times puts on: for when the earth is so situated between the sun and the moon, that we see all her enlightened parts, it is full moon: when the moon is so situated between the sun and the earth, that her enlightened parts are hid or turned from us, it is new moon; and when her situation is such that only a portion of her enlightened part is hid from us, we see a horned moon, a half moon, or a gibbous moon, according to the quantity of the enlightened part we can perceive.

But I will endeavour to explain this to you more clearly, says our philosopher, taking an ivory ball suspended by a string, in his hand; we will suppose this ball to be the moon, the candle the sun, and my head the earth. When I place the ivory ball in a direct line betwixt my eye and the candle, it appears all dark, because the enlightened part is opposite the candle; but if I move the ball a little to the right, I perceive a streak of light, which is like the new moon; if the ball is moved further, it presents the appearance of a half moon; move it still further, until all the enlightened part is seen, it appears like a full moon.

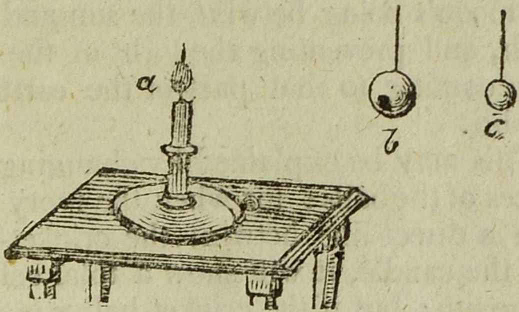
I think it is extraordinary, says Tom Wilson, that the moon, which you say is so much smaller than the sun, should appear to our sight equally large.

That is easily explained, replied our philosopher, for if you consider that the sun is at 400 times a greater distance from us than the moon, your objection is answered; but this I will explain further in treating of eclipses.

I have frequently observed, says Master Lovelace, that the moon appears much larger when just rising above the horizon, than she does afterwards; I should like to know the cause of that. It is occasioned, replies our philosopher, by the fogs or exhalations that arise from the earth, which magnify objects seen through them; thus the moon appears larger until she rises above these fogs.

The total or longest eclipse of the moon happens when the earth is directly between the sun and the moon, and prevents the light of the sun from falling upon and being reflected by the moon; as you will understand by looking at the figure I have drawn, for the purpose of giving you a clear idea of this phenomenon.

We



We will suppose the candle *a*, to be the sun; the cricket-ball *b*, to be the earth; and the ivory ball *c*, to be the moon. A string being tied to each of the balls, I tie them up to the ceiling, or any other support, in a direct line from the light of the candle; the cricket-ball about eight inches from the candle, and the ivory ball about two inches from the cricket-ball. Whenever the earth and moon come in the position of these balls, a total eclipse of the moon ensues; because the light of the candle (or sun) shining on the cricket-ball (or the earth) totally obscures or eclipses the ivory ball (or the moon); but if we move the ivory ball a little higher up, or lower down, so that the light from the candle may pass by the cricket-ball and shine upon part of the ivory ball, it will of course be only partially eclipsed.

An eclipse of the sun is occasioned by

the moon's being betwixt the sun and the earth, and preventing the light of the sun from coming to that part of the earth we inhabit.

This may be explained by changing the places of the balls; for when the ivory ball is in a direct line betwixt the cricket-ball and the candle, it will show a total eclipse of the sun; but if the cricket-ball is moved a small degree higher up or lower down, so that the light from the candle shines a little upon it, it will show only a partial eclipse.

But I should be glad to be informed, says Charles Harris, how the sun, which is so much larger than the moon, can be totally eclipsed from our sight, by the moon coming betwixt us and it?

That is what I intended to explain to you, replied the lecturer. If you place your cricket-ball in a direct line between your eye and the sun, it will entirely hinder you from seeing it, although your ball is so much smaller than the sun: because the ball, though too diminutive to conceal the sun, is yet large enough to obstruct the rays of light that fall upon your eye.

An eclipse of the sun never happens but at a new moon, nor one of the moon but when she is at the full.

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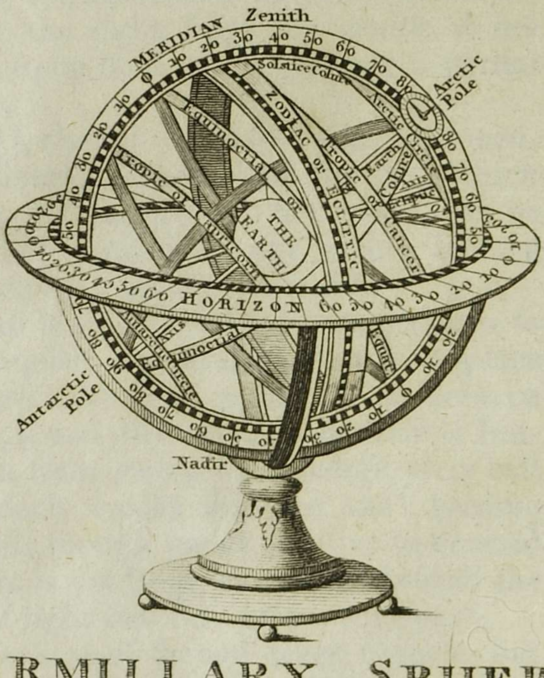
THE MOON



ARMILLARY SPHERE

The moon consists of mountains and valleys, not unlike those belonging to our earth; and its appearance is very beautiful when seen through the telescope I showed you some time ago.

The livid spots and bright streaks of light are supposed to be the mountainous parts; and the same parts being constantly turned towards the earth, she always presents the same side to us. The dark parts were formerly imagined to be seas; but from later observation it is proved, that they are hollow places or caverns, which do not reflect the light of the sun.

The earth, by its revolution about the sun in 365 days, 5 hours, and 49 minutes, measures out that space of time which we call a year; and the line described by the earth in this annual revolution about the sun, is called the ecliptic. By an inspection of the armillary sphere you will have a perfect idea of this and other circles necessary to be known.

The annual motion of the earth round the sun is at the amazing rate of 68,243 miles every hour. If the earth moves with such extreme velocity, says one of the young ladies, it is very surprising that we do not perceive its motion.

That proceeds from the equability of the motion: If you have ever enjoyed the pleasure of sailing on smooth water, you must remember, that on looking through the cabin window, it seemed rather as if the objects on land moved by you swiftly, than that the vessel you were in passed by them. Now, the earth glides through the ether with less obstruction and irregularity, than any body can do through the water; and consequently its motion is imperceptible to the creatures that inhabit its surface.

Besides this annual motion or revolution about the sun in the line of the ecliptic, the earth turns round upon its own axis in about 24 hours; so that it hath two motions at one and the same time.

No familiar object that I can recollect, will represent this double motion so exactly, as the wheel of a carriage running round a circle; the wheel turns round its own axis, at the same time it runs along the circular road.

This was easily comprehended by the whole company; and the philosopher proceeded to explain still more astronomical principles, by the assistance of the terrestrial globe.

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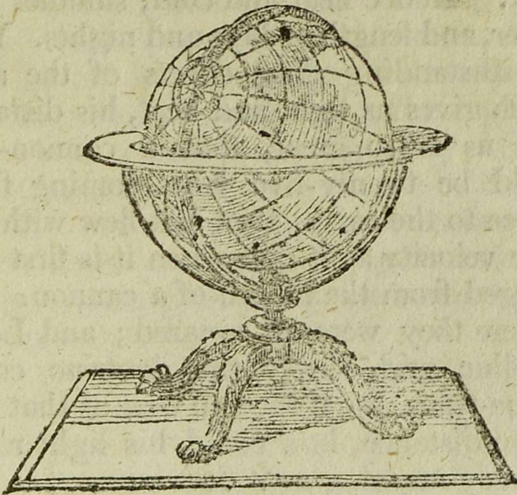

The revolutions of the earth on its own axis produces the agreeable changes of day and night; for those parts of the earth that are turned towards the sun are enlightened by its rays, whilst those that are turned from it will be involved in darkness.

But the length of days and nights, and the variations of the seasons, are occasioned by the annual revolution of the earth about the sun in the ecliptic; for as the earth, in this course, keeps its axis equally inclined every where to the plane of the ecliptic and parallel to itself, the earth, in this direction, has sometimes one of its poles nearest the sun, and sometimes the

other,

other. Hence heat and cold, summer and winter, and length of days and nights. Yet, notwithstanding these effects of the sun, which gives us light and heat, his distance from us is so great, that a cannon-ball would be twenty-five years coming from thence to the earth, even if it flew with the same velocity as it does when it is first discharged from the mouth of a cannon.

Here they were all amazed; and Lady Caroline said, surely this doctrine could not be true: for if the sun were at that immense distance, how could his light reach us every morning as it does now.

The velocity of light is indeed inconceivable, which, travelling 95 millions of miles, the distance between our planet and the sun, reaches us in nearly eight minutes, and must, consequently, move about 200,000 miles in a second of time.

But if you are so surprised at the sun's distance, what will you think of the fixed stars, which are so remote from us, that a cannon-ball, flying with the same velocity as when first discharged, would be 700,000 years in coming to the earth? Yet many of these stars are seen even without the use of telescopes.

There are other things observable in our solar system, which, if attended to, would excite

excite our admiration: such as the dark spots which are seen on the sun's disk, and which often change their number and magnitude. Such also is the amazing ring which encompasses the body of the planet Saturn; and such are the belts that gird the body of Jupiter: concerning all which there are various conjectures; but conjectures in philosophy are rarely to be admitted.

LECTURE

LECTURE III.

Of the Air, Atmosphere, and Meteors.

The curiosity and astonishment of the young company being excited by the wonders of the solar system, they were earnest in their entreaties to Mrs. Mentor to fix another afternoon for a philosophical lecture, which she did the earliest opportunity; for she thought that such subjects not only enlarged the understanding, but raised emotions of gratitude and admiration of the great Creator's wisdom and goodness, so eminently displayed in the order and harmony of the planetary system.

Mr. Telescope having made his appearance, the young people seated themselves, with countenances full of expectation, when he opened his lecture in the following manner:

Having already considered the earth as a planet, and observed its diurnal and annual motion; we are now to speak of the materials of which it is composed, and of the atmosphere and the meteors that surround and attend it.

In order to explain these effectually, says Mrs.

Mrs. Mentor, I think you should begin with giving us an account of the first principles of the four elements, which I suppose we all know are fire, air, earth, and water; and then show how they affect each other, and by their mutual aid give motion, life, and spirit to all things: for without fire, the water would assume a different form, and become solid ice; without water, the fire would scorch up the earth, and destroy both animals and plants; without air, the fire would be unable to execute its office; nor without air, could the water, though exhaled by the sun into clouds, be distributed over the earth for the nourishment of plants and animals. Nor is the earth inactive, but lends her aid to the other elements; for she, by reflecting the sun's beams, occasions that warmth which nourishes all things on her surface; but which would be very inconsiderable and scarcely felt, if a man were placed on the highest mountain above the common level of the earth, and in such a situation as to be deprived of her reflection.

All this, madam, I have considered, replied the philosopher; and had thoughts of carrying it further, and showing how those elements pervade, and are become indeed constituent parts of the same body; for

for fire, air, earth, and water, are to be drawn even from a dry stick of wood. That two sticks rubbed violently together will produce fire is very well known; for coach or waggon-wheels frequently take fire when not properly clouted with iron, and supplied with grease; and if pieces of wood, seemingly dry, be put into a glass retort over a furnace, both air and water may be obtained; and then if you burn the wood to ashes; and wash out the salts with water, as the good women do when they make lye, the remaining part will be pure earth: and thus we can, at any time, draw the four elements out of a stick of wood. But as these speculations would render our lecture a study rather than an amusement, I shall defer the consideration of such minute and abstruse matters till another opportunity. Science is to be communicated as children are taught the use of their legs; at first they are shown how to stand alone; afterwards, to walk with safety; and then suffered to run as fast as they please: and I beg you will permit me to pursue this method in the course of my lectures." Mrs. Mentor assented to his design with a smile of approbation, and our philosopher thus proceeded:

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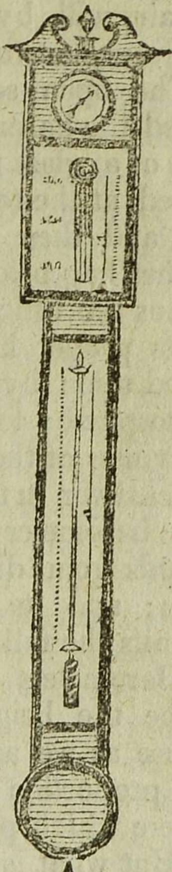
The air is a light, thin, elastic or springy body, which may be felt but not seen; it is fluid, and runs in a current like water; (as you may perceive by opening the window;) but it cannot, like water, be congealed into ice: and the atmosphere is that great body or shell of air which surrounds the earth, and which reaches many miles above its surface, as is known by considering the elasticity or springiness of the air and its weight together; for a column of air is of equal weight to a column of quicksilver of between 29 and 30 inches high. Now quicksilver being near four times heavier than water, if the air were as heavy as water, the atmosphere would be about fourteen times higher than the column of quicksilver, or about 34 feet; but the air is near 1000 times lighter than water; therefore the atmosphere must be many miles high, even at this rate of computing. And when with this you consider the elasticity of the air, which, when the pressure of the incumbent atmosphere is taken off, will dilate itself so as to fill more than 150 times the space it occupied before, you will perceive that the height of the atmosphere must be very great. For as the air is a springy body, that part next the earth must be more dense or thick than the upper part, as being pressed down by the air above it. Look at that hay-stack yonder, which the groom is cutting, and you will perceive that the hay at the bottom is much closer, and harder to cut than that at the top, because it has been pressed into a less space than it otherwise would have occupied, by the other hay above it; and had not the whole stack been trodden and pressed down by the men who made it, the difference would have been still more considerable.

The air, however, even near the earth, is not always in the same state. It is sometimes rarefied, and becomes lighter than at other times, as appears by the quicksilver's falling in the barometer, and the rain's descending on the earth.

It may serve to illustrate the subject we are upon, says the young philosopher, to explain the construction of that triple weather-glass that I see hanging up before me. So walking up to it, he described it in the following manner: The uppermost instrument contained in the round brass box, is called the hygrometer, (marked *a.*) It consists of a brass plate, divided into degrees both ways, right and left, from 0 to 180. To the left is engraved *moist*, and to the right *dry*. In the centre of the plate is fixed the beard of a wild oat, with a piece of straw glued to it, as an index. The index is first set to



0 of the divisions, so that any change of the air which happens afterwards in the room to *moist* or *dry*, the beard, by twisting or untwisting itself from the action of

the air, will, by the index, point it out accordingly on the scale.

The open square part next below, is called the barometer, (marked *b.*) It consists of a glass tube about 32 inches long, closed at the top, first filled with quicksilver, and then inverted on a reservoir or leather bag below, of quicksilver. By this means the quicksilver in the tube subsides to its proper height, accordingly as it is acted upon by the pressure of the air or atmosphere; for it is the dense state, or heaviness of the air, that presses upon the quicksilver in the reservoir, and raises it in the barometer; this also prevents the clouds from distilling through the air in rain; and its lightness, on the contrary, admits the fall in showers, &c.

Barometers are likewise used to determine the heights of mountains, &c. because as we ascend, the quicksilver rises in proportion; the weight of the atmosphere which presses on it being less.

But what is the use of that screw at the bottom of the instrument? says Master Wilson. I thank you for the question, says the philosopher; for many a young ignoramus has totally spoiled a good barometer, by foolishly playing with that screw till they forced it up, broke the bag, and

let

let out all the quicksilver. Let it be particularly known, that this screw is only provided by the instrument-maker, to force up the quicksilver in its tube, in a gentle manner, so that in conveying the instrument into the country or abroad, it is thus made portable, and not liable to have the tube broken by the concussion of the quicksilver against the top of the tube. The next instrument below is called the thermometer, (marked *c.*) It contains a long glass tube, partly filled with quicksilver, and screwed down to a brass scale, on which are marked divisions and terms of various degrees of heat and cold, from boiling water down to freezing, found and adjusted by actual trial of the maker. The freezing point is marked 32, and the boiling water 212. This is called Fahrenheit's Scale, from the name of the inventor. The heat of the air expands the quicksilver in the ball, and it accordingly rises in the tube; whereas, on the contrary, cold contracts the quicksilver, and it of course falls; so that at any time by mere inspection, the change of the temperature of the air is immediately shown.

The elastic principle in the air, which renders it so capable of being rarefied and condensed, has been productive of the most wonderful effects. But before you proceed further, says Lady Caroline, pray do me the favour, Sir, to convince me by some experiment, that the air is endowed with this wonderful quality. I will prove that to your satisfaction, if Master Wilson will lend me the pop-gun he was making this morning. Do me the honour to step this way, Lady Caroline. You see here is a pellet in the top of this tube, made of hemp or brown paper. With this piece of paper we will make another pellet, and put it into the other end. Now with the gun-stick drive it forward. There, you have forced the pellet some part of the way with ease; but it will be more difficult to get it further, because the air, being compressed and made more dense or compact, will make more resistance; and when you have pressed it so close that its force overpowers the resistance which the pellet makes at the other end, that pellet will fly off with a bounce, and be thrown by the spring of the air to a considerable distance. There, see with what force it is thrown!

This simple operation has not excited your attention, because it is a school-boy's action, and is seen every day; for, indeed, we seldom trouble ourselves to reason about things that are so familiar; yet, on this

principle

principle depends the force of a cannon: for it is not the gun-powder and fire that drive out the ball with such prodigious velocity; no, that force is occasioned by the fire's suddenly rarefying the air which was contained in the chamber or breech of the cannon, and that generated by the powder itself. As a proof of this, place the same ball in the same quantity of powder in an open vessel, and when fired you will scarcely see it move. But there have been guns lately invented, called air-guns, which sufficiently prove what I have advanced; for they are charged only with concentrated or condensed air.

I have provided one, with the rest of my instruments, for the purpose of illustrating this principle. Please to observe, that there is a small hollow globe previously filled by a syringe with condensed air, which is screwed under the back, and by pulling the trigger a valve is opened in the globe by a pin; the air rushes

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from thence, through the back into the barrel against the bullet, and drives it to a great distance: the air in the globe is sufficient to discharge six or seven bullets, one after the other; each of which would kill a buck or a doe at a very considerable distance.

You seem all amazed, and I do not wonder at it, since you have never yet considered the extraordinary properties of this element; and it must seem strange to you, that the air, which is so necessary for life, that without it we cannot breathe, should be tortured into an instrument of destruction. You will, however, be more surprised when I tell you that this is probably the cause of earthquakes; and that the noble city of Lisbon was some years ago destroyed by a sudden rarefaction of the air contained in some of the caverns of the earth, and perhaps under the sea. An expression of doubt appeared on Tom Wilson's countenance, but he restrained himself from again exposing his ignorance. Lady Caroline took more courage, and declared that she could not believe what he had said about earthquakes; for, says she, I remember to have read in the news-papers, that the flames burst out of the ground. That might be, my lady, says

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the philosopher; for there could be no such sudden rarefaction of the air without fire. Fire, therefore, did contribute towards the earthquake; and fire might burn down a mountain composed of combustibles, but fire could never blow one up. Be assured, that effect is the sole property of the air; a truth, of which further experiments will convince you.

I hope every one of the company has a clear idea of the signification of the air's being rarefied and condensed. In the first case it becomes thinner, and is expanded; in the second, the particles are compressed closer together, and are confined in a closer space.

In this property of being rarefied and condensed, the air differs amazingly from water, which, though composed of such small particles as not to be distinguished or seen separately with a microscope, and notwithstanding its readiness to rise or be evaporated with heat, and to be separated with a touch, cannot, when confined, be at all concentrated, or brought into a less compass.

I have already intimated that heat is the efficient cause of all fluidity, and that ice may therefore be termed the natural state of water. The utility of this diluting power of heat to man, as well in digesting his food

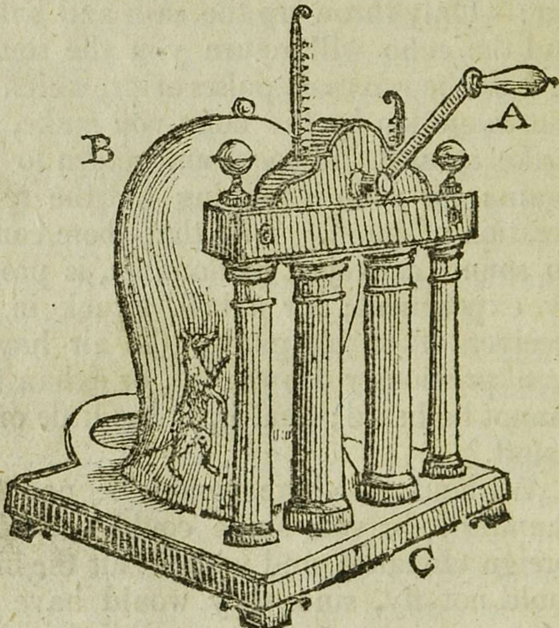
food as in increasing his enjoyments in various modes, it would be tedious minutely to describe. Water, thus rendered fluid, by containing a quantity of air, is the medium of respiration to aquatic animals. It is also, if not the principal, at least a considerable part of the food of vegetables; which will appear, when that part of nature comes under our consideration.

By increasing the heat, water is rendered elastic and volatile; that is, is converted into vapour, the force of which, when confined, is almost incredible: this force has been applied to the use of mechanics in the steam engines, by which it is said, that a single drop of water, converted into vapour, is capable of raising several hundred weight. The construction of these engines being so very complicated, it is impossible for me to explain them without proper models.

Air is the medium which diffuses light to the world; for if there were no atmosphere to refract or bend the sun's rays round the globe, it would be almost as dark in the day-time as in the night; and the sun, moon, and stars, would only be visible.— It is also the medium of sounds, which are conveyed by the tremulous motion of the air when agitated by any noise. Let me throw this peach-stone into the moat, and you will perceive circles of small waves diffuse themselves by degrees to a great distance round it. Now, as the air is fluid as well as the water, we may conclude that sound is conveyed somewhat in this manner; though, as that is nearly a thousand times lighter than water, sounds are propagated at an amazing rate: some say, after the rate of 1,142 feet in a second of time; but however that may be, we may rest assured that sound is conveyed in this manner:—Only throw up the sash and halloo, and the echo will return you the sound; that is, the waves or pulses of air, which are put in motion by the noise you make, will strike against the rocks and return to you again: for echo is nothing but the reverberation of sound. And that there can be no sound conveyed without air, is proved by experiment; for a bell, struck in the receiver of an air-pump, the air having been previously drawn out, or exhausted, cannot be heard; that is, it has little or no sound.

Without air there would be no merchandise; for your ships could not sail to foreign climates; and without air the birds could not fly, since they would have nothing to support them, and their wings would

would be useless; for we know that a feather falls with as much velocity as a guinea in an exhausted receiver of an air-pump. But above all, air is the principle which preserves life both in plants and animals: there is no breathing without air; and you know, when our breath is stopped, we die. This is one of those truths that are called self-evident; because it is universally known, and needs no confirmation. It is a cruel experiment to put animals into the receiver of an air-pump after the air has been



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drawn out; therefore I will not distress your feelings by displaying such a painful object before you; it will be sufficient to relate what I have seen, to confirm the truth of my assertion, that no animal can live without air.

All that I have said concerning the weight and elasticity of the air is demonstrated in the most simple and elegant manner by the air-pump. For by working the handle, (marked *A*,) all the air that is contained within the glass receiver (marked B) is pumped out; and if any living animal is put within the receiver, all the air in its body is pumped out likewise: then, air being the principle which preserves life, the animal dies, unless fresh air be immediately admitted, which may be done by turning a screw at (C). I have seen a rat, a frog, and a bird, and any creature would be the same, put into the receiver (B); and when the air was nearly exhausted, they appeared convulsed and in great agony; and more air being pumped out, they fell on their sides as dead; but fresh air being immediately admitted, it rushed into their lungs, which put them in motion again, and they recovered. The manner of the animal's recovery puts me in mind, says Mrs. Mentor, of an accident which I once saw, and which I would have you all remember; for it may be of service on a similar occasion. Some time ago several boys were bathing in a river; one of them, who was an obstinate, silly boy, determined to outdo his companions by running into dangers and difficulties; and with this view, though he could swim no more than a stone, he plunged into a part of the river, which he was told was greatly above his depth, where he rose and struggled to get out, but could not. His companions were all in the utmost distress, and unable to assist him, for none of them could swim. At this instant some gentlemen on horseback came up, who immediately dismounted, and got him out; but not till after he had sunk the third time. He was brought to the shore, without signs of life, and let blood without any effect; when one of the gentlemen, who I have since heard was a great philosopher, advised them to blow some air down his throat; this was done, and the elasticity of the air put his lungs in motion, as I imagine, for a pulsation immediately ensued: he recovered almost as soon as this animal. Now, from what I heard that gentleman say, and from the instance before us, there is reason to believe that the lives of many might be saved, who are

are supposed to be drowned, if this method was put in practice, of conveying air to the lungs; for unless the lungs are in motion there can be no circulation: and I suppose it was for want of air that their motion ceased in the water.

Mr. Telescope desired the company to observe, that air which has passed through fire, or is become foul or stagnated, and has lost its spring, is unfit for respiration. It was the want of fresh air, said he, or, in other words, the being obliged to breathe air that was foul, and had lost its spring, or elastic force, that some years ago killed so many of our poor countrymen in the Black Hole at Calcutta in the East Indies: and this breathing of foul air in inflammatory, putrid, and eruptive disorders; such, for instance, as the small-pox, and some fevers, has destroyed more than can be imagined. If, therefore, you should be seized with any of these disorders, advise the people about you to make use of their common sense, and not, because a man is ill, deprive him of that vital principle the air, without which he could not live, even in a state of health. Never suffer your curtains to be drawn close, or exclude the fresh air, even when you sleep.

I am greatly mistaken, says Lady Caroline, if the air we are now in has not lost its spring; for I breathe with difficulty. Were that the case, Madam, replied the philosopher, you would not be able to breathe at all; but if you find a want of air, you should make use of the instrument that lies by you, which, by putting the air in motion, will, in part, recover its spring. What instrument, Sir? says the lady. Your fan, Madam, returned the philosopher. Every fan is a philosophical instrument, and was originally contrived, we may suppose, for the purpose above mentioned.

A bird dying in an air-pump will be, in some measure, recovered by the convulsive fluttering of its own wings; because that motion alters the state of the air remaining in the receiver, and for a time renders it fit for respiration.

Motion is the only preservative for air and water; both of which become unwholesome if kept long in a state of rest; and both may be recovered and made salutary by being again put in motion.

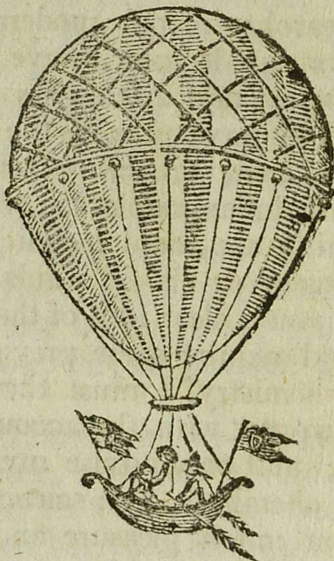
Since foul and stagnated air has such dire effects, how much are we obliged to the learned and ingenious Dr. Hales for discovering the ventilator: an instrument which, in a little time, discharges the foul

air

air from ships, prisons, and other close places, and supplies them with that which is fresh!

The researches of our modern philosophers, says our lecturer, have been the means of many new discoveries in regard to air. They have proved the existence of many different sorts of air: such as our common air, inflammable air, nitrous air, and mephitic air, more technically denominated gasses or elastic fluids. But to convey to you a clear idea of these distinctions, would require some previous knowledge of chemistry, I must therefore beg leave to dispense with the account of these at present; and only advise my hearers to a study of chemistry, as a science that will afford them much pleasure and information in nature's wonderful operations.

When you mentioned inflammable air, says Master Wilson, I thought you would have described the balloon; which, of all wonders I think the greatest. It perplexes me to account how it is possible for any large hollow substance, even although filled with air, to float in the atmosphere, particularly when weighed down with a boat and two men in it, as represented in this picture, which records the memorable event of Mr. Blanchard and Dr. Jefferies crossing the English Channel from Dover to France.



I am surprised at so simple a question, says our philosopher. Why, surely you never considered the reason of those balls mounting in the air, that I have seen you make by soap and water beat to a lather, and blown out of the bowl of a tobacco-pipe. The air by which they are blown, issuing from your lungs, is specifically lighter than the common air, even when contained in that thin watery globe. Now, inflammable air is about ten times lighter than

than common air; so that a large hollow silk balloon, filled with inflammable air, although loaded with a boat, two men, and other articles, is lighter in its bulk than common air; and consequently, when released from the cords that fasten it to the ground, it rises majestically, and soars along in and above the clouds, according to the direction of the wind.

We are now to speak of the wind, which is only a stream or current of air, as a river is of water, and is occasioned by heat, eruptions of vapours, condensations, rarefactions, the pressure of clouds, the fall of rains, or some other accident that disturbs the equilibrium of the air: for nature abhors a vacuum or empty space; and for that reason, when the air is extremely rarefied in one part, that which is more dense will immediately rush in to supply the vacant places, and preserve the equilibrium; as is the case with water and other fluid substances. Raise a vessel of water suddenly out of a cistern, and see with what speed the other water will rush in, to fill up the space and preserve its level. And these rarefactions in the air may happen near the earth, or much above it; and is the reason why clouds fly in contrary directions. This occasioned the

loss

loss of the great kite, which you were a whole fortnight in making; for though there was scarcely wind in the park sufficient to raise it, yet when lifted extremely high by the air, it was seized by a current of wind, and torn in pieces.

Winds are violent or gentle, in proportion to the rarefaction or disturbance there has been in the atmosphere. A violent wind, in a great storm, flies after the rate of 50 or 60 miles in an hour; and is sometimes so dense, or strong, as to bear down trees, houses, and even churches before it. What the sailors call a brisk wind, flies after the rate of about 15 miles an hour, and is of great use in cooling the air, and cleansing it from poisonous and pestilential exhalations.

The winds have various qualities; they are generally hot or cold, according to the quarter from whence they blow. I remember, some years ago, we had a south-west wind in February, which blew so long from that quarter, that it brought us the very air of Lisbon; and it was as hot as in summer. Winds from the north and north-east, which come off large tracts of land, are generally cold. Some winds moisten and dissolve, others dry and thicken; some raise rain, and others disperse it:

some

some winds blow constantly from one quarter, and are therefore called the general trade winds; these are met with on each side of the equator, in the Atlantic, Ethiopic, and Pacific Oceans. Some winds, again, blow constantly one way for one half, or one quarter of the year, and then blow the contrary way. These are met with in the East Indian seas, and are called monsoons, or periodical trade winds. But as these subjects are abstruse and difficult, and afford little entertainment, I will defer an explanation of them at present, and endeavour to give you some account of the meteors that attend the air.

We have already observed, that, besides pure air, the atmosphere contains minute particles of different sorts, which are continually arising in streams from the earth and waters, and are suspended and kept floating in the air.

The most considerable of these are the small particles of water; which are so separated as to be lighter than air, and are raised by the sun's heat, or lifted up by the wind from the sea, rivers, lakes, and marshy or moist parts of the earth; and which descend again in dews, rain, hail, and snow.

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When many of these small particles are, by a rarefied state of the air, suffered to unite, and descend so as to render the hemisphere more opaque, and by its humidity to moisten bodies on the earth, it is called a mist. And, on the contrary, those particles of water that arise, after a hot day, from rivers, lakes, and marshy places, and, by filling the air, moisten objects and render them less visible, are called fogs.

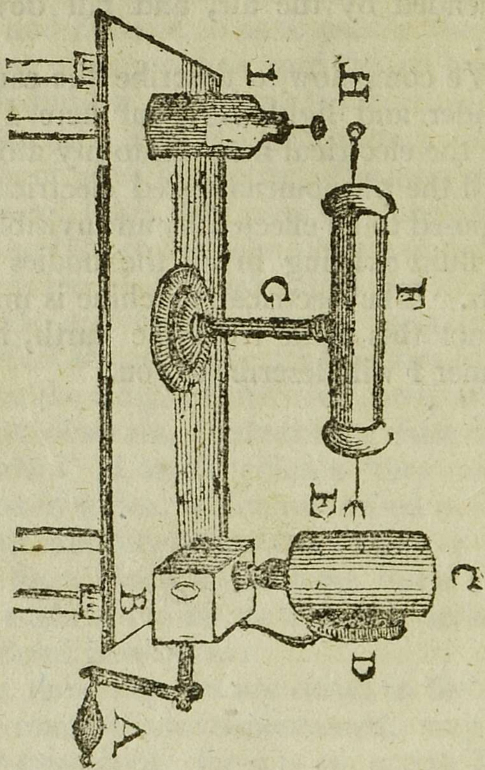
Clouds are the greatest and most beneficial of all the meteors; for they are borne about on the wings of the wind, and, as the Psalmist observes, "distribute fatness to the earth." Clouds contain very small particles of water, which are raised a considerable distance above the surface of the earth; for a cloud is nothing but a mist flying high in the air, as a mist is nothing but a cloud here below.

That these vapours are raised in the air, in the manner above-mentioned, may be readily conceived; for it is an action that is seen every day in common distillations; but how these invisible particles which float in the air, are collected into clouds, in order to bring the water back again, is not so easy to determine. It is probable, that by uniting first into small drops, then into

into larger, they become too heavy to be suspended by the air, and fall down in rain.

We come now to describe the causes of thunder and lightning; but here I must take the electrical machine to my aid.

All the phenomena called electrical, are supposed to be effected by an invisible subtile fluid existing in all the bodies of the earth. The electrical machine is made to extract this fluid from the earth, in the manner I will describe to you.



The handle (marked A) being turned round, by means of some wheelwork in the box (marked B) turns round the glass cylinder (marked C): this cylinder rubs against the cushion of stuffed silk, which is called

called the rubber (marked D:) by this means the electric fluid is extracted from the rubber, and carried round by the glass to the point (marked E,) which it enters, and remains in the tin tube or conductor (marked F,) which is fixed upon a glass stem (marked G:) as the electric fluid cannot pervade glass, this stem hinders it from returning again to the earth. When the machine is worked, if a person places one of his knuckles about half an inch from the brass knob at the end of the conductor (marked H) the electric fluid will dart, like a bright spark of fire, from it to the knuckle, and give him a small degree of pain. If, instead of the knuckle, a coated jar is placed to the conductor (I,) the fire will be received by it and accumulated in it: so that if a person touches the bottom of the jar with one hand, and the ball at the top of it with the other, he will receive the charge of electricity through him, and feel the sensation of a sudden shock.

The similarity of lightning and electricity is not to be remarked in a few appearances only, but is observable throughout all their various effects. Lightning destroys edifices, animals, trees, &c. it always goes through the best conductors, such as metal or water; but if it meets with substances which will not conduct it, such as stone or wood, it rends them, and disperses them in every direction. Lightning burns, and often melts metals and other substances. All these effects, as I said before, may be produced by electricity. But besides the great similarity existing between lightning and electricity, what fully proves them to be the same is, that the matter of lightning may be actually brought down from the clouds by means of electrical kites: but as this is a very dangerous experiment in unskilful hands, I will not now describe the method of making them. Clouds have almost always some electrical matter in them; and the lightning, accompanied with the thunder, which is supposed to be collected from the earth, is only that matter darting from one or more clouds into another cloud, or else upon the earth; in which case it strikes upon the most lofty and pointed places, and by this stroke produces all those dreadful effects that are known to be occasioned by lightning. But, says Lady Caroline, I have been told, that those pointed iron rods, that I have sometimes seen fixed on the top of large buildings, are a protection against lightning. That they certainly are, said Mr. Telescope; for the lightning is attracted from

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the clouds by the pointed rod, and conducted down the side of the building, to the nearest water, without damaging it. These rods were the invention of the late ingenious Dr. Franklin, of America. People in general, when they happen to be caught in a thunder-storm, run for shelter under a tree; but that is very dangerous; for the lightning is attracted by the tree, and thus accidents often happen. The best way is, to get into an open place, and lay at a distance all metal which you may have about you: if you do this, you are not in much danger of being hurt by the thunder and lightning.

Snow is the small particles of water frozen in the air before they had united into drops: and hail is drops of rain frozen in the fall.

The *Aurora Borealis*, or northern lights, are occasioned by certain nitrous and sulphureous vapours which are thinly spread through the atmosphere 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, the streams of which seem to converge towards the zenith of the spectator, or that point of the heavens which is immediately over his head.

At this instant up started Master Long, and asked leave to enquire, whether the appearance of the *Jack-with-a-lantern* that had been seen in the park, could be accounted for on rational principles; for it had led one of his friends, who was passing that way late one evening, a strange dance. The night being dark he missed his way; but just as he came into the marshy meadow he observed a light, and supposing it to be some neighbour with a lantern, he followed it, it still running before him, till he found himself in the pond. His cries alarmed some cottagers returning from their work, who helped him out, and told him some ridiculous stories of the light that had misled him, calling it *Jack-with-the-lantern*, or *Will-with-the-Wisp*; and supposing it some evil spirit who delights in doing mischief.

The *Ignis Fatuus*, *Jack-with-a-lantern*, or *Will-with-the-Wisp*, as it is frequently called, is supposed to be only a fat, unctuous, and sulphureous vapour, which in the night appears lucid; and being driven about by the air near the earth's surface, is often mistaken for a light in a lantern. Vapours of this kind are, in the night, frequently kindled in the air; and some of

them

them appear like falling stars, and are by ignorant people supposed to be so.

It may be here necessary to mention that beautiful phenomenon the rainbow, since it has the appearance of a meteor, though, in reality, it is none; for the rainbow is occasioned by the refraction or reflection of the sun's beams from the very small drops of a cloud or mist seen in a certain angle made by two lines, the one drawn from the sun, and the other from the eye of the spectator, to those small drops in the clouds which reflect the sun's beams: so that two persons looking on a rainbow at the same time, do not, in reality, see the same rainbow. The appearance of a rainbow may be produced by turning your back to the sun, and forcing water out of a syringe against a dark wall or shady place; the causes being the same on a smaller scale, as the rainbow in the sky.

There are other appearances in the atmosphere which ought to be taken notice of; and these are the halos, or circles, which sometimes seem to encompass the sun and moon; and are often of different colours. These always appear in a rainy or frosty season, and are therefore, we may suppose, occasioned by the refraction of light in the frozen particles in the air.

Here the lecture would have ended, but a sudden clap of thunder brought on fresh matter for meditation. Some of the company, and particularly the ladies, endeavoured to avoid the lightning; but Mr. Telescope, after the second clap, threw up the sash, and assured the ladies and gentlemen there was no danger, for that the clouds were very high in the air. The danger, in a thunder-storm, says he, is in proportion to the violence of the tempest and the distance of the clouds; but this tempest is not violent; and that the cloud is at a great distance, or high in the air, you may know by the length of time there is between your seeing the flash of lightning and hearing the clap of thunder. Look, see how the sky opens to emit the fire! presently you will hear the thunder; for you know we see the fire from a gun at a distance, long before we hear the report. There it is! and how tremendous! These tempests always put me in mind of that beautiful passage in Shakespeare's King Lear: where, when the good old king is out in a storm, and obliged to fly from his unnatural children, he says,

——— Let the great Gods
That keep this dreadful thund'ring o'er our heads,

Find

Find out their enemies now. Tremble, thou wretch,
That hast within thee undivulged crimes
Unwhipt of justice! hide thee, thou bloody hand,
Thou perjur'd, and thou simular of virtue,
That art incestuous! Caitiff, shake to pieces,
That under covert, and convenient seeming,
Has practis'd on man's life! Close pent-up Guilt,
Rive your concealing continents, and ask
These dreadful summoners grace!——
This tempest will not give me leave to ponder
On things would hurt me more———

Poor naked wretches, wheresoe'er you are,
That bide the pelting of this pitiless storm!
How shall your houseless heads, and unfed sides,
Your loop'd and widow'd raggedness defend you
From seasons such as these?—O, I have ta'en
Too little care of this! Take physic, Pomp,
Expose thyself to feel what wretches feel,
And thou may'st shake the superflux to them,
And show the Heavens more just.

LECTURE

LECTURE IV.

Of Mountains, Springs, Rivers, and the Sea.

We come now, says the philosopher, to the consideration of things with which we are more intimately acquainted, but which are not, on that account, the less wonderful. How was that mountain lifted up to the sky? How came this crystal spring to bubble on its lofty brow, or that large river to flow from its massy side? But above all, how came this mighty body of water, the sea, so collected together? and why and how was it impregnated with salt, seeing the fish and other animals taken out of it are perfectly fresh? These are questions not to be answered even by the sages in science. Here the wisest of mankind, after having studied to the utmost limits of his faculties, and lost in admiration, can only say with the Psalmist, "They that go down to the sea, and occupy their business in the great waters, "these men see the greatness of God, and "his wonders in the deep.—Wonderful "are thy works, O Lord; in judgment "hast thou made them all!—The earth is "full of thy greatness!"

It

It is the business of philosophy, however, to enquire into these things, though our enquiries are sometimes vain. We shall therefore, in this lecture, give the best account we can of mountains, springs, rivers, and the sea.

The ancients supposed that mountains were originally occasioned by the deluge. Before that time they imagined the earth to have been a perfect level: and a certain abbot was taken into custody and punished for asserting that the earth was round; though there is so great a necessity for its being so, that, according to the properties with which the Almighty has endowed the substances that compose the world, it could not conveniently subsist in any other form: for, not to mention the formation of rivers, which are generally occasioned by the mists that fall on the mountains; if the earth was a regular plain, instead of that beautiful variety of hills and valleys, of verdant forests and refreshing streams, which at present delight our senses, a dismal sea would cover the whole face of the globe; and at best it would be only the habitation of fishes.

Does not this assertion, says Lady Caroline, question the power of the Creator? How can you tell that the earth and water thus

thus disposed, would have that effect?—From daily experience, says the philosopher. Throw this stone into the moat, and you will see it sink; or this clot of dirt, and it will fall to the bottom. But, says she, this is not always the case; for when I water my flowers, the water sinks into the ground and disappears.—That is, because there is abundantly more earth than water, Madam, says he; and the earth being porous, or hollow, the water runs into the cavities, and fills them; but were you to continue pouring out of the water-pot till all these crevices were full, you would find the water flow at top, and the garden-mould, or earth would remain at the bottom; for if you take a pint pot of earth, and another of water, and mix them ever so well together, the earth will, in a little time, subside or fall to the bottom, and the water will be seen at the top. This is to me a demonstration; and it is so far from calling in question the wisdom of God, that it is vindicating his wisdom in the works of creation. So that you may perceive from hence, as well as from the motion of the heavenly bodies, that the earth is round, and that the ancients were in an error.

And with regard to mountains, though the deluge might throw up some, and much alter the face of the earth, yet, from the great use mountains are of in collecting the waters of the atmosphere into springs and rivers, it is reasonable to suppose there were mountains even in the first age of the world.

I have heard the irregularity of the earth's surface attributed to a stroke from the tail of a comet, a great many thousand years ago, said Miss Gray, what is your opinion of this conjecture?

I am unable to answer for all the extravagant conceits and ridiculous follies that have entered the heads of ignorant people, says he; and you might as well expect me to give a reason for the poor soldier's prophesying an earthquake, and of the terrors of the people on that occasion, as to account for this. That the earth has undergone amazing changes since its first formation, is, I think evident from the contents of some mountains, even in our own country; in which we find not only petrifactions in abundance, but the shells of sea-fish, and even the bones of animals, that were never inhabitants of this climate. At Reading in Berkshire, which is above forty miles from the sea, there is a stratum

of

of oyster-shells, which appear like real oysters, and are spread through a hill of considerable extent; they lie upon a chalky rock in a bed of sand, much resembling that of the sea; and the upper part of the hill which is a loamy soil, is thirty or forty feet perpendicular above them: and at Burton near Petworth, in Sussex, was dug out of a pit the bones or skeleton of an elephant. Numberless curiosities of this kind have been discovered here, some of which I shall take particular notice of in my next course of lectures; but I think there are few but what may be accounted for from the effects of the deluge, earthquakes, and subterraneous fires. Earthquakes at the bottom of the sea, for instance, have sometimes thrown up mountains or little islands, with the fish upon them, which have been covered by the sandy or loose earth giving way, and falling over them. It is not long since an island was raised in this manner, in the Archipelago, of ten miles in circumference, the hills of which abound with oysters not yet petrified, and which are much larger than those taken on the coast; whence we may conclude, that they were thrown up from the deepest part of the sea. Sea-fish have been also found in other mountains;

some

some of which have been petrified; while others have been found with the flesh only browned or mummied.

And from the amazing quantity of fire contained in the earth, and the consequent rarefaction of the subterranean air, great alterations must have been made in its surface in the course of so many years.

At this rate, said Lady Caroline, you will persuade us that the inside of the earth is a mighty furnace, ready to consume us whenever it bursts forth.

I should be sorry to alarm you, said Mr. Telescope, with false fears; nor, should my position be true, is there any cause for apprehension; but you may be assured that there are numbers of these furnaces in the earth, a fact that is evidently proved by the great number of burning mountains, which are continually sending up flames, attended with large stones and metallic substances. Some particulars of these eruptions, from the best authority, shall satisfy your doubts; when, taking a book out of his pocket, he read as follows:

"The most famous of these mountains is Ætna in Sicily, whose eruptions of flame and smoke are discovered at a great distance, by those that sail on the Mediterranean, even as far as the harbour of Malta, which is forty German miles from the shore of Sicily. Though fire and smoke are continually vomited up by it, yet at some particular times it rages with greater violence than usual. In the year 1536 it shook all Sicily, from the first to the twelfth of May; after that there was heard a most horrible bellowing and cracking, as if great guns had been fired; there were a great many houses overthrown throughout the whole island. When this storm had continued about eleven days, the ground opened in several places, and dreadful gapings appeared here and there, from which issued forth fire and flame with greal violence, which in four days consumed and burnt up every thing that was within five leagues of Ætna. A little after, the funnel, which is on the top of the mountain, disgorged a great quantity of hot embers and ashes for three entire days together, which were not only dispersed throughout the whole island, but also carried beyond sea to Italy; and several ships that were sailing to Venice, at two hundred leagues distance, suffered damage. Facellus hath given us an historical account of the eruptions of this mountain; and says, that the bottom of it is one hundred leagues in circuit.

"Hecla,

"Hecla, a mountain in Iceland, rages sometimes with as great violence as Ætna, and casts out great stones. The imprisoned fire often, from want of vent, causes horrible sounds, like lamentations and howlings; which make some credulous people think it the place of hell, where the souls of the wicked are tormented.

"Vesuvius in Campania, not far from the town of Naples, though it nourishes the most fruitful vines, and, when undisturbed, yields the best Muscadel grapes, yet it is very often annoyed with violent eruptions. Dion Cassius relates, that in the reign of Vespasian, there was such a dreadful eruption of impetuous flames, that great quantities of ashes and sulphureous smoke were not only carried to Rome by the wind, but also beyond the Mediterranean, into Africa, and even into Egypt. Moreover, birds were suffocated in the air, and fell down dead upon the ground: and fishes perished in the neighbouring waters, which were made hot and infected by it. There happened another eruption in Martial's time, which he elegantly describes in one of his epigrams, and laments the sad change of the mountain, which he saw first adorned with verdure, and immediately after discoloured with ashes and embers. When the burning ceased, the rain and dew watered the surface of the mountain, and made these sulphureous ashes and embers fruitful, so that they produced a large increase of excellent wine; but when the mountain began to burn again, and to disgorge fire and smoke afresh, (which sometimes happened within a few years,) then were the neighbouring fields burnt up, and the highways made dangerous to travellers.

"A mountain in Java, not far from the town of Panacura, in the year 1586, was shattered to pieces by a violent eruption of glowing sulphur; (though it had never burnt before;) by which, as it was reported, ten thousand people perished in the underland fields. It threw up large stones, and cast them as far as Panacura; and continued for three days to throw out so much black smoke, mixed with flames and hot embers, that it darkened the face of the sun, and made the day appear as dark as the night."

There is a great number of other volcanoes, or, as your ladyship is pleased to call them, furnaces, in the known world; but to enumerate them would be too tedious to my auditors.

We come now to the consideration of springs;

springs; which are occasioned principally, we may suppose, by the water exhaled from the sea, rivers, lakes, and marshy places; and forming clouds, are dispersed by the winds. These clouds, when they are so collected together as to become too heavy to be supported by the air, fall down in rain to water the herbs and plants; but those that are lighter, being driven aloft in the air, dash against the mountains, and to them give up their contents in small particles; whence entering the crevices, they descend till they meet together, and form springs; and this is the reason why we have such plenty of springs in mountainous countries, and few or none in those that are flat. And you may observe that it frequently rains in hilly countries, when it is clear and fine in the valleys beneath; for the air in the valleys is dense enough to support the clouds, and keeps them suspended; but being driven up among mountains, where, in consequence of their height, the air is so much lighter, they descend in mists or such small drops of rain that will not run off, as is the case in a heavy rain, but sink into the crevices of the earth, in the manner already mentioned. Now, that a great part of this water is exhaled from the sea, may be known by the extraordinary rains and great dews which fall upon islands that are surrounded by the sea; but some springs, it is reasonable to suppose, have their source from the ocean, since those which we meet with near the sea are generally rather salt or brackish.

These springs, thus formed by the mists on mountains, and the rain meeting together, form little rivulets or brooks; and those again uniting, compose large rivers, which empty themselves into the sea: and in this manner the water, exhaled from the sea by the sun, is returned to it again; for Providence has established such wise laws or regulations for the world, that no part of the element can be annihilated. But the very large rivers must have some other source besides the springs formed by the mists, dews, and rains, since these seem insufficient to support their prodigious discharge; it is therefore no improbable conjecture, to suppose that they have some communication with the sea, and that the salt water is purified and rendered sweet by passing through the sand, gravel, and crevices of the earth.

Lakes are collections of water contained in the cavities of the surface of the earth; some of which are said to be stagnant, and made up of the waste water that flows, after

rain

rain or snow, from the adjacent countries; and these must be unwholesome.—Other lakes are supplied by rivers, the contents of which they receive and convey under ground, to form other springs and rivers: others, again, are fed by springs which arise in the lake itself; and some, as that of Haerlem, and other salt lakes, have a communication, it is supposed, with the sea, whence they receive their waters, and afterwards discharge them by subterranean streams.

The sea is a great collection of water in the deep valleys of the earth; I say, in the deep valleys; for if there were not prodigious cavities in the earth to contain this amazing quantity of water thus collected together, the whole surface of the globe would be overflowed; for the water being lighter than the earth, would be above the earth, as the air is above the water.

Now you speak of the sea, says Mrs. Mentor, I wish you would tell me why the sea-water is always salt. Madam, replied he, I wish I could; but it is beyond the reach of my philosophy, and indeed, I believe, of any philosopher whatever; although some have conjectured, that the rivers, in their passage, extract the salts from the earth and convey them to the sea.

I have

I have often thought, from the prodigious quantity of salt distributed in the earth and water, that it must have qualities which we know not of, and answer purposes in the scale of being with which we are unacquainted.

The most remarkable quality in the sea, next to its saltness, is that motion or rising and falling of the water, that we call tides, and which is occasioned by the attraction of the moon, as I mentioned in my second lecture; (page 24;) for that part of the water in the great ocean, which is nearest the moon, being strongly attracted, is raised higher than the rest; and the part opposite to it, on the contrary side, being least attracted, is also higher than the rest; and these two opposite sides of the surface of the water, in the great ocean, following the motion of the moon from east to west, and striking against the large coasts of the continent, from thence rebound back again, and so make floods and ebbs in narrow seas and rivers, at a distance from the great ocean. This also accounts for the periodical times of the tides, and for their constantly following the course of the moon.

LECTURE V.

Of Minerals, Vegetables, and Animals.

Could a philosopher condescend to envy the great, it would not be for their sumptuous palaces and numerous attendants, but for the means and opportunities their riches afford them of enquiring into the secrets of nature, and contemplating the wonderful works of God. There is no subject so worthy of a rational creature, except that of promoting the happiness of mankind; and none, except that, can give a man of refined taste and good understanding, so much real satisfaction. But it is our misfortune that few engage in those enquiries but men of small estate, whose circumstances will not permit them to spare the time, nor support the expence of travelling, which is often necessary to obtain the knowledge they seek after; and for the want of which they are obliged to depend on the relations of those who have not, perhaps, been so accurate or so faithful as they ought. Considering the quantity of foreign drugs that are used in Britain, it is amazing how little even those who deal in them know of their nature or peculiarities; so little, indeed, that they cannot tell where they grow, or how they are found or manufactured; are unable to distinguish the genuine from the fictitious, and may, therefore, through mistake, often substitute the one for the other. Health and life are of too much consequence to be trifled with; yet these are neglected, while fashion, dress, and diversions, are sought after throughout the world. This is a melancholy consideration; but, you may say, it is no part of our lecture, therefore we shall drop a subject which has thrust itself, as it were, into our way, and speak of the contents of the earth, and its products and inhabitants: for this globe, besides the earth and water, which are necessary for the production and support of plants and animals, contains other materials which have been found useful to man. That reflecting telescope, this gold watch, and Lady Caroline's diamond ear-rings, were all dug out of the earth; at least the materials were there found, of which these things are composed.

Those sorts of earth, which, with the assistance of rain, produce vegetables or plants in such abundance, are common mould,

mould, loam, clay, and sandy soils. There are earths also that are different from these, and which are used in medicine; as the Japan earth, Armenian Bole, &c.

The barren parts of the earth are, for the most part, sand, gravel, chalk, and rocks; for these produce nothing unless they have earth mixed with them. Of barren sands there are various kinds, though their chief difference is in their colour; for the sand which we throw on paper to prevent blotting, and that the maid throws on the floor, are both composed of little irregular stones, without any earth: and of such there are large desarts in some parts of the world, and one in particular, where Cambyses, an eastern monarch, lost an army of 50,000 men. Sure, says Lady Caroline, you must mistake, Sir. How was it possible for a whole army to be lost in that manner. It is easily accounted for from phenomena that frequently happen in those parts, returned the philosopher: the wind raised the sands in vast clouds, for many days together, till the whole army was smothered. And if you read the life of Alexander the Great you will find, that his army was in great danger when he crossed the same desart, in his frantic expedition to visit the temple

temple of his pretended father, Jupiter Ammon.—But let us return to our subject.

Besides these materials, which compose the surface of the earth, if we dig deeper, we frequently find bodies of a nature very different; and these, because they are discovered by digging into the bowels of the earth, are called by the common name of fossils: though under this head are included all metals and metallic ores, minerals, or half-metals, stones of various sorts, petrifactions, or animal substances turned into stone; and many other bodies which have a texture between stone and earth: as oker of several sorts, with one of which the farmers colour their sheep; black lead, that is so valuable in making those pencils that we use for drawing; and some kinds of chalk, sea-coal, and other bodies that are harder than earth, and yet not of the consistency of perfect stone.

Of stones there is an amazing variety. They are classed by naturalists under two heads; that is to say, spars and crystals: and by others, into vulgar and precious stones. Some of the most considerable, both for beauty and use, are marble, alabaster, porphyry, granite, free-stone, &c. Flints, agates, cornelians, and pebbles, under which kind are placed the precious stones,

stones, otherwise called gems or jewels, which are only stones of an excessive hardness, and which, when cut and polished, have an extraordinary lustre. The most valuable of these are diamonds, rubies, sapphires, amethysts, emeralds, topazes, and opals.

But there are other stones which, though void of beauty, may, perhaps, have more virtue than many of those already mentioned; such as the loadstone, which I described to you in my first lecture (page 9;) also the whetstones, with which we sharpen our knives and other edge-tools; limestones, talc, calamine, or lapis calaminaris, and many others.

Besides the bodies already mentioned, there are also found in the earth a variety of salts; such as rock-salt or sal-gem, vitriol, nitre, and many others.

The minerals, marcasites, or semi-metals, as they are called by the chemists, are antimony, zink, bismuth, &c. These are not inflammable, ductile, or malleable, but are hard and brittle, and may be reduced to powder; and the first, after melting, may be calcined by fire.

Mercury, or quicksilver, has generally been classed with semi-metals, and indeed, sometimes among the metals; but I think it ought not to be classed under either of these heads, but considered separately; as also should brimstone, though it be a part of the composition of crude antimony.

Ores are those kinds of earth which are dug out of mines, and contain metallic particles, from whence metals are extracted.

Their form, when dug from the mine, is very different from that which they assume when they have been melted in the furnace, and polished by the art of man. The most precious metals, as gold and silver, do not form the most splendid ores. The pyrites, which are a mixture of iron and sulphur, are much more beautiful to the eye.

The trade of a miner is the most wretched and dangerous of all occupations; they are not only exposed to the common accidents of the roof falling in, or a sudden overflow of water, but also to a variety of *damps*, as they are called, or noxious vapours. In the quicksilver mines the sufferings of the workmen are deplorable; their bodies are so impregnated with the mineral, that they soon become emaciated and crippled, every limb contracted or convulsed; and in a short period end their miserable existence in a consumptive state: all this they sustain for the trifling reward of seven-pence a day.

Metals are distinguished from other bodies, by their weight, fusibility, or melting in the fire, and their malleability, or giving way and extending under the stroke of the hammer without breaking in pieces. These are six, viz. gold, silver, copper, tin, lead, and iron. They are seldom or never found in any part of the earth but what is mountainous, which, by the way, in some measure proves what we ventured to assert in a former lecture, viz. that there were mountains before the deluge; for that there were metals before that time, appears by what is said in holy writ concerning Tubal Cain, who wrought in brass, &c. and was the inventor of organs.

What sort of bodies are to be found deeper in the earth, I mean towards its centre, is unknown to us; for we have hitherto only been able to make ourselves acquainted with the fossils contained in its shell, and the vegetables and animals on its surface; whose nature and properties alone are, probably, so numerous and complicated, as to exercise the enquiry of man to the end of time.

Of Vegetables or Plants.

The vegetables or plants growing on the earth, may be divided into three classes ; I mean those of herbs, shrubs, and trees.

Herbs are those sorts of vegetables whose stalks are soft, and have no wood in them ; as parsley, lettuce, violets, pinks, grass, nettles, thistles, and an infinite number of others.

Shrubs are those plants which, though woody, never grow into trees, but bow down their branches near the earth's surface. Such are those plants that produce roses, honeysuckles, gooseberries, currants, and the like.

But trees shoot up in one great stem or body, and rise to a considerable distance from the ground before they spread their branches ; as may be seen by the oak, the beech, the elm, the ash, the fir, the walnut-tree, cherry-tree, &c. From the bodies of trees, we have our timber for building ; and of the oak-tree in particular for ship-building, no timber being so tough, strong, and durable, as English oak : neither does any tree, perhaps, yield more timber ; for there was one lately sold for forty pounds, from Langley woods, belonging to the Bishop

of

of Salisbury, which measured six feet, two inches in diameter, contained ten tons of timber, and was supposd to be a thousand years old.

" From a small acorn see the oak arise
Supremely tall and tow'ring to the skies!
Queen of the groves, her stately head she rears,
Her bulk increasing by the length of years:
Now ploughs the sea a warlike, gallant ship,
Whilst in her womb destructive thunders sleep.
Hence Britain boasts her wide extensive reign,
And by th' expanded acorn rules the main."

The most considerable parts of plants are, the root, the stalk, the leaves, the flowers, and the seed; most of them have these several parts, though there are some, indeed, that have no stalk, as the aloe; others that have no leaves, as savine; and others that have no flowers, as fern. But I think there are none without root or seed.

What most excites our wonder with respect to plants, and what, indeed, has been the subject of much dispute among the learned, is their nourishment and mode of propagation. I have often heard my father, said one of the young gentlemen, converse on these subjects when we were amusing ourselves in the garden, but I paid too little attention to his remarks to remember them; I shall therefore thank you to tell us how they receive their nourishment, and what are the best means of propagating their species. A disquisition of this nature, says the philosopher, would take up too much of your time, and could not be understood without reciting many experiments and observations that have been made by the learned: I shall therefore defer the consideration of it at present. The reply to the question is so easy, says Master Wilson, that I see no reason why you should defer it. Do not they receive their nourishment from the earth? and if the seeds of old plants are sown will not they produce new ones.

In order to speak to the purpose, Master Wilson, says the philosopher, you should be better acquainted with the subject. The earth has not, perhaps, so much to do with the nourishment of plants as is generally imagined; for, without water, and particularly rain-water and dew, there could be but little increase in vegetables of any kind; and this you may know by the languid state of plants in a dry season, though watered ever so often from the river or well. This is known also by the small quantity of earth which is taken up in the growth of plants; for both Mr. Boyle and Dr. Woodward

Woodward raised several plants in earth watered with rain or spring-water, and even distilled water; and upon weighing the dry earth both before and after the production of the plants, they found that very little of it was diminished or taken up by the plant. Taken up by the plant! says Lady Caroline, in some surprise; why, you do not imagine there is earth in herbs and trees? Indeed, I do, Madam, replied the philosopher, and have already hinted this opinion in what was said on the four elements; and at the same time I observed, that it might be extracted from the plant, by burning the plant to ashes, and washing off the salts, as your laundry-maid does when she makes lye; for when these salts are washed away, the remainder will be earth.

If the earth contributes so little towards the production of plants, says Master Blyth, the water, I apprehend, must be a good deal concerned; and that is evident from the quantity of water which most plants require to keep them in a state of health and vigour. Your observations, says the philosopher, deserve some notice; but how will you account for the growth of plants in sandy desarts, where it seldom rains, and of plants too that contain juices in

great

great abundance? for God Almighty, for the preservation of his creatures, has caused those wonderful plants to grow in such barren desarts, to supply, in some measure, the want of water; and some are so constructed as to hold great quantities of water for the use of animals. This is the case of the ground-pine, which, though it seems to grow like a fungus or excrescence on the branch of a tree, often contains a pint or a quart of sweet water for the birds, beasts, and even men, to refresh themselves with in the sultry climates where they abound. But a plant may hold much water for the subsistence of animals, and yet not subsist on water itself; and that this is the case experience testifies. Dr. Woodward put a plant of spearmint, which weighed 27 grains, into a phial of water, where it stood 77 days, and in that time drank up 2558 grains of spring-water: and then being taken out, weighed 42 grains; so that the increase was only 15 grains; which is not an hundredth part of the water expended.

What nourishment the plant obtains from the earth and water, is generally supposed to be received by the fibres of the roots, and conveyed, by the stalk or body of the plant, up into the branches and leaves,

leaves, through small tubes, and then returned by the bark to the root again; so that there is a constant circulation of vital fluids in plants as well as in animals. But I am inclined to think, that a great part of the nourishment of plants is received by the pores of the leaves and skin, or bark, as well as from the root; else how happens it that plants are so much refreshed by the dew.

Air is as necessary to the nourishment of plants as a circulation of these alimentary juices; for they respire as well as animals, and for that respiration require fresh air, and even exercise; since we know, that plants that are always confined in a close room will never rise to perfection: and it is evident that they perspire, from the instance of the mint growing in spring-water above mentioned; for, if not a hundredth part of the water taken up by that plant became a part of the plant itself, all the rest must be perspired through the pores or little imperceptible holes in the skin and leaves. This recalls to my mind, says Lady Caroline, a charge my father gave me, never to sit in the yew-arbour; because, said he, the matter perspired by the yew-tree is noxious, and will make you ill;

and

and I believe that was the reason of his ordering that old arbour to be demolished.

But pray Sir, why, and in what manner do plants perspire? For the same reason, and in the same manner, perhaps, that animals do, returned the philosopher. It is occasioned, probably, by heat; for we know they perspire much more in summer than in winter; nay, when this vegetative principle has been long checked by cold, it breaks out with such force when warm weather comes on, that it is no uncommon thing, in the cold northern countries, to see the trees covered with snow one week, and with blossoms the next.

Plants are propagated different ways; but the most general method is by seed. Some plants, however, are raised by a part of the root of the old plant set in the ground, as potatoes; others, by new roots propagated from the old ones, as hyacinths and tulips; others, by cutting off branches, and putting them into the ground, which will take root and grow, as vines; and others are propagated by grafting and budding, or inoculation.

Of Animals.

We are now to speak of the animals that inhabit the earth, which are naturally divided into men and brutes.

Of men there seem to be four different sorts.—Nay, do not be frightened, Lady Caroline!—Sir, says she, I should have made no objection, had you said four hundred, provided you had distinguished them according to their different dispositions.—True, Madam, says the philosopher, or according to their different features, and then you might have said four hundred thousand; for it is very true, Madam, though very wonderful, that out of four hundred thousand faces you will not find two exactly alike; and but for this miraculous and gracious providence in God, the world would have been all in confusion. But the division I would willingly make of men, is, that of white, tawny, black, and red; and these, you will allow are, with respect to colour, essentially different. Most of the Europeans, and some of the Asiatics, are white; the Africans on the coast of the Mediterranean Sea are tawny; those on the Coast of Guinea black; and the original Americans red, or of a red copper colour.

Perhaps this difference arises from the very long influence of climate on the same race, or from some cause that escapes our observation. Without being able to give you a reason for its being so, I only state the fact, which must have been obvious to you all, as you must occasionally have seen Africans and Asiatics, if not some of the other races, who are more rare in this country.

Brutes may be divided into four classes; that is to say: 1. Aërial, or such as have wings, and fly in the air, as birds, wasps, flies, &c. 2. Terrestrial, or those which are confined to the earth; as quadrupeds, or four-footed beasts: reptiles, which have many feet; and serpents, which have no feet at all. 3. Aquatic, or those that live in the water; as fish of all kinds, whether they are covered with scales or shells, or are, like the eel, without either. 4. Amphibious, or those that can live for a long time either upon the earth or in the water; as otters, aligators, turtles, &c. I say for a long time, because I apprehend that the use of both these elements are necessary for the subsistence of those animals; and that though they can live for a considerable time upon land in the open air, or as long in the water, excluded in a manner from

air,

air, yet they would languish and die if confined entirely either to the one or the other of these elements.

In this division of animals we are to observe, however, that there are some which cannot be considered under either class, being, as it were, of a middle nature, and partaking of two kinds: thus, bats seem to be partly beasts and partly birds. Some reptiles, likewise, and some of the water-animals, want one or more of the five senses with which others are endowed; as worms, cockles, oysters, &c.—If I mistake not, says Lady Caroline, I have seen the animals divided into different classes in books of natural history, and described under the heads of beasts, birds, fishes, and insects. Very true, says the philosopher, but the method I have chosen suits my present purpose the best, and can make no alteration in the nature of things; however, as I have not yet mentioned the word insects, though they are included in my division of animals, it may be necessary for me to observe, that they are so called, from a separation in their bodies, by which they are seemingly divided into two parts, those parts being only joined together by a small ligament; as in flies, wasps, &c. Some of these insects undergo different changes, and in time become quite different animals. There is something so amazing and miraculous in the transformation of insects, that I am lost in reflection whenever the subject strikes my mind; and sometimes I am inclined to think that other animals may undergo some such change. Who that had not made the observation, would think, Madam, that this grub, crawling or rather sleeping here, would by-and-by become a fine butterfly, decked out in all the gaudy colours of the rainbow; or that this silkworm should be capable of assuming so many different forms! And is it not altogether as miraculous, that if some animals are cut in pieces, every separate piece or part of the original animal will become one entire animal of itself: yet, that the polype or polypus is endowed with this property has been demonstrated; and I have here one that was divided into several parts some time ago, which parts are now become distinct and perfect polypes, and alive; as you may see by viewing them through this microscope.

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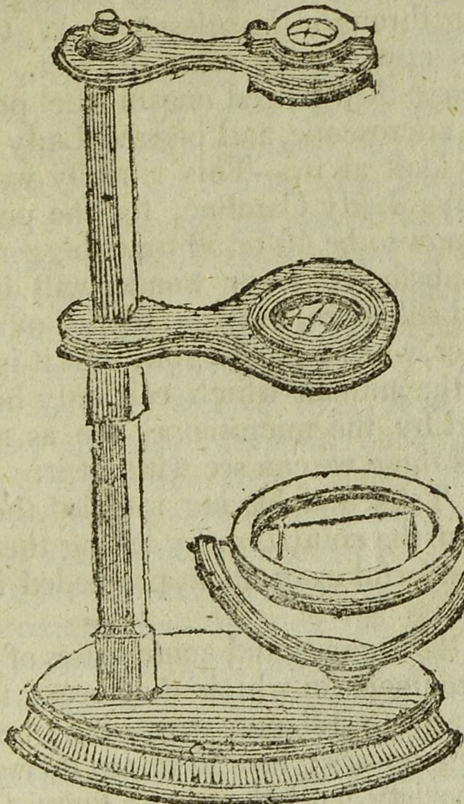

The part marked A, contains the magnifying glasses. The object to be examined is placed at the stage B, between a hollow and a plane glass; the light is reflected upon it by the mirror C. To adjust the object to the glasses, you move the stage B, up or down upon the pillar, while you are looking through the glasses at A, till the objects appear the most distinct. Mr. Telescope then placed one of the polypes in the microscope, and begged Lady Caroline to look at it.—This is really wonderful, says Lady Caroline, for the polypus seems now to be 40 or 50 times bigger than it was before. Your wonder will be increased still more, Madam, replied our philosopher, when I inform you, that it is supposed the animals which can only be discovered by the microscope, are as numerous as those we can see without it.

Mr. Telescope having satisfied the curiosity of the company, by letting them see this wonderful instrument, proceeded in his lecture.

But the sagacity and acute senses of some of the animals (in which they seem to exceed man) are still more surprising: beavers building houses; bees forming themselves into a society, and choosing a queen to govern them; birds knowing the latitude and longitude, and sailing over sea through vast tracts of air, from one country to another, without the use of any compass; and other things, which are sufficient, I think, to lower the pride of man, and make even

philosophers

philosophers blush at their own ignorance. —And now, Lady Caroline, prepare to hear a few hard words, and I will finish this lecture. But why must it be finished in an unintelligible manner? says the lady. Because I cannot deliver what I am going to say, without making use of the terms of art; and I would recommend to all my young friends to make an occasional study of these terms, as a means of attaining science with greater facility.

All animals receive their food at the mouth; and most animals, but especially those of the human kind, chew it there till it is intimately mixed with the saliva or spittle, and thereby prepared for the easier and better digestion of the stomach. When the stomach has digested the food, it is thence conveyed into the guts, (pardon the expression, for I cannot avoid it,) through which it is moved gently by what is called the peristaltic motion; as it passes there, the chyle, which is the nutritive part, is separated by the lacteal veins, from the excrementitious parts, and by them conveyed into the blood, with which it circulates, and is concocted into blood also; and this circulation is thus performed:—The blood being, by the *vena cava*, brought into the right ventricle of the heart, by the contraction of that muscle, is forced into the pulmonary artery of the lungs; where the air, which is continually inspired or drawn in by the lungs, mixes with and enlivens it; and from thence, the blood being conveyed by the pulmonary vein into the left ventricle of the heart, the contraction of the heart forces it out, and by the arteries distributes it into all parts of the body; from whence it returns by the veins to the right ventricle of the heart, to pursue the same course again, in order to communicate life and heat to every part of this wonderful machine, the body. But this is not all; for, according to anatomists, some part of the blood, in the course of its circulation, goes to the head; where a portion of it is separated by the brain, and concocted into animal spirits, which are distributed by the nerves, and impart sense and motion throughout the body. The instruments of motion, however, are the muscles; the fibres or small threads of which, contracting themselves, move the different parts of the body; which, in some of them, is done by the direction of the mind, and therefore called voluntary motion; but, in others, the mind seems not to be concerned, and these motions are accordingly called involuntary.

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This is the progress of animal life; by which you will perceive that a man may, even at home, and within himself, see the wonders of God in the works of creation.

We have now finished our survey of the universe, and considered these great masses of matter, the stars and planets; but particularly our earth and its inhabitants; all which large bodies are made up of inconceivably small bodies, or atoms: and by the figure, texture, bulk, and motion of these insensible corpuscles, or infinitely small bodies, all the phenomena of large bodies may be explained.

LECTURE VI.

Of the Five Senses of Man, and of his Understanding.

THE holidays being almost over, and the young people having nearly concluded their visit, Mr. Telescope attended the summons of Mrs. Mentor to give them some further instruction, in order to complete the slight survey he had taken of the visible creation. Every one was curious to know what topic would be chosen after the sky, the earth, and the water, had undergone an examination; but none of them were able to guess, that the theme of the philosopher would be that of all others with which they should be best acquainted, even the faculties and intellectual powers of their own minds.

After the company was properly adjusted, and an attentive silence prevailed, Mr. Telescope addressed them with the following remarks:

After the cursory view of nature, which was concluded in my last lecture, it may not be amiss to look within ourselves and examine our own faculties, and see by what means we acquire and treasure up knowledge; and this is done, I apprehend, by means of the senses, the operations of the mind, and the memory, which last may be called the storehouse of the understanding. The first time a little child is brought to a looking-glass he thinks he has found a new play-mate, and calls out, Little boy! Little boy! for having never seen his own face before, it is no wonder that he should be unacquainted with it. Here is the idea, therefore, of something new acquired by sight. Presently the father and mother and nurse come forward, to partake of the child's diversion. Upon seeing these figures in the glass, with whom he is so well acquainted, he immediately calls out, There papa! there, mamma! there, nurse! and now the mind begins to operate; for feeling his father's hand on his own head, and seeing it on the little boy's head in the glass, he cries, There me! Now this transaction is lodged in the memory, which, whenever a looking-glass is mentioned, will give back to the mind this idea of its reflecting objects.

This familiar demonstration gave general satisfaction, and he proceeded thus:— All our ideas, therefore, are obtained either by sensation or reflection; that is to say, by means of our five senses: as seeing, hearing, smelling, tasting, and touching, or by the operations of the mind.

Before you proceed further, says Mrs. Mentor, you should, I think, explain what is meant by the term idea. That, I apprehend is sufficiently explained by what was said about the looking-glass, says the philosopher; but if you require another definition, I will give it you. By an idea, then, I mean that image or picture, Madam, which is formed in the mind, of any thing which we have seen or even heard talk of; for the mind is so adroit and ready at this kind of painting, that a town, for instance, is no sooner mentioned, but the imagination shapes it into form, and presents it to the memory. None of this company, I presume, have ever seen Paris; yet there is not one, perhaps, but has formed, or conceived in his mind, some idea or picture of that city. Not one of us ever saw Tippoo Saib's prodigious army and elephants, yet we have all formed to ourselves a picture of their running away from a small party of our brave countrymen, led against them by the gallant and courageous Cornwallis. When we read in the newspapers a description of a sea engagement, or of the taking of Louisburg, Quebec, or

any

any other important fortress, the mind immediately gives us a picture of the transaction, and we see our valiant officers issuing their orders, and their intrepid men furling their sails, firing their guns, scaling the walls, and driving their enemies before them. To pursue this subject a little farther: no man has ever seen a dragon, a griffin, or a fairy; yet every one has formed in his mind a picture, image, or, in other words, an idea of these imaginary beings. Now when this idea or image is formed in the mind from a view of the object itself, it may be called an adequate or real idea; but when it is conceived in the mind without seeing the object, it is an inadequate or imaginary idea.

I shall begin my discourse of the senses with that of the sight, because, as Mr. Addison observes, the sight is the most perfect and pleasing of them all. The organ of seeing is the eye, which is made up of a number of parts, and so wonderfully contrived for admitting and refracting the rays of light, that those which come from the same point of the object, and fall upon different parts of the pupil, are again brought together at the bottom of the eye; and by that means the whole object is painted

painted on a membrane called the retina, which is spread there.

But how is it possible, says Master Wilson, for you to know that the object is thus painted on the retina? In some measure from the structure of the eye, replied the philosopher; but I think it is manifest from that disorder of the eye, which surgeons call the *gutta serena*; the very complaint which the little boy in the cottage near the park-gate has in one of his eyes. If you examine it, you will find that he has no sight with that eye, though it looks as perfect as the other, with which he sees well; this is, therefore, occasioned by some paralytic, or other disorder in that membrane or expansion of the optic nerve, which we call the retina; and proves that all vision arises from thence.

That which produces in us the sensation which we call seeing, is light; for without light nothing is visible. Now light may be considered, either as it radiates from luminous bodies directly to our eyes; and thus we see these luminous bodies themselves; as the sun, a lighted torch, &c. or as it is reflected from other bodies; and thus we see a flower, a man, &c. or a picture reflected from them to our eyes by the rays of light.

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It is to be observed, that the bodies which respect the light are of three sorts, 1. Those that emit the rays of light; as the sun and fixed stars; 2. Those that transmit the rays of light, as the air: and, 3. Those that reflect them; as the moon, the earth, iron, &c. The first we call luminous, the second pellucid, and the third opaque bodies. It is also to be observed, that the rays of light themselves are never seen; but by their means we see the luminous bodies, from which they originally came; and the opaque bodies, from which they are reflected: thus, for instance, when the moon shines, we cannot see the rays which pass from the sun to the moon; but, by their means, we see the moon, from whence they are reflected.

If the eye be placed directly in the medium, through which the rays pass to it, the medium is not seen; for we never see the air through which the rays come to our eyes. But if a pellucid body, through which the rays are to pass, be placed at a distance from our eye, that body will be seen, as well as those bodies from whence the rays came that pass through it to our eyes. For instance, he who looks through a pair of spectacles, not only sees bodies through them, but also sees the glass itself; because the glass being a solid body, reflects some rays of light from its surface; and being placed at a convenient distance from the eye, may be seen by those reflected rays, at the same time that bodies at a greater distance are seen by the transmitted rays; and this is the reason, perhaps, why objects are seen more distinctly through a reflecting than through a refracting telescope.

There are two kinds of opaque bodies; namely, those that are not specular; as the moon, the earth, a man, a horse, &c. and others that are specular, or mirrors, like those in reflecting telescopes, whose surfaces being polished, reflect the rays in the same order as they come from other bodies, and show us their images; and rays that are thus reflected from opaque bodies, always bring with them to the eye the idea of colour, though this colour in bodies is nothing more than a disposition to reflect to the eye one sort of rays more copiously, or in greater plenty than another; for particular rays impress upon the eye particular colours; some are red, others blue, yellow, green, &c. Now it is to be observed, that every body of light which comes from the sun, seems to be compounded of those various sorts of rays; and as some of them

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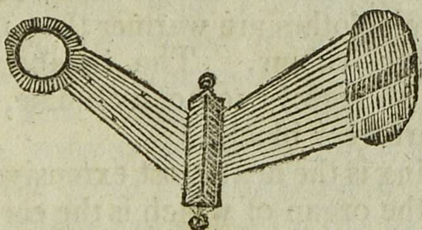
are more refrangible than others, that is to say, are more turned out of their course in passing from one medium to another, it necessarily follows that they will be separated after such refraction, and their colours appear distinct. The most refrangible of these are the violet; and the least the red: the intermediate ones, in order, are indigo, blue, green, yellow, and orange.

How do you know that colours are separated in this manner, says Lady Caroline; in order to be convinced that it is really so, I must have further demonstration. This triangular piece of glass is adapted to the purpose.



If you please to hold it in the beams of the sun, you will see the colours separated in the manner I have mentioned. Please to look, Mrs. Mentor; the separation is very pleasing, and you will find what I have said of the rainbow in my third lecture, confirmed by this experiment.

All these rays differ not only in refrangibility, but in reflexibility; I mean the property some have of being reflected more easily than others; and hence arise all the various colours of bodies.

The whiteness of the sun's light is owing, it is supposed, to a mixture of all the original colours in a due proportion; and whiteness in other bodies is a disposition to reflect all the colours of light nearly in the same proportion as they are mixed in the original rays of the sun: as blackness, on the contrary, is only a disposition to absorb or stifle, without reflection, most of the rays of every sort that fall on those bodies; and it is for that reason, we may suppose, that black clothes are warmer than those of any other colour. The inhabitants of Naples, though in so hot a climate, for the most part wear black.

Hearing is the next most extensive of our senses, the organ of which is the ear, whose structure is extremely curious; as may be seen in the books of anatomy.

That which the ear conveys to the brain is called sound, though, till it reaches and affects the perceptive part, it is, in reality, nothing but motion; and this motion, which produces in us the perception of sound, is a vibration of the air occasioned

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by a very short and quick tremulous motion of the body from whence it is propagated. That sound is conveyed in this manner, may be known by what is observed and felt in the strings of musical instruments, and of bells, which tremble or vibrate as long as we perceive any sound come from them; and from this effect which they produce in us, they are called sounding bodies.

Sound is propagated at a great rate, but not near so fast as light. I don't know that, says Lady Caroline. Then you have forgotten what passed in our lecture upon air, replied the philosopher; and to confirm by experiment what I advanced, I must beg leave to order one of the servants to go to a distance in the park, and discharge a gun. Mrs. Mentor, to gratify the young people, ordered her game-keeper out; and when the piece was discharged, they had the satisfaction of seeing the fire long before they heard the report.

The effect is the same, says our philosopher, in thunder-storms, for we perceive the flash of lightning before we hear the thunder; and the more distant the storm is from us, the greater is the space of time between the flash and report.

Smelling is another sense which seems to be excited in us by external bodies, and sometimes by bodies at a great distance; but that which immediately affects the nose, the organ of smelling, and produces in us the sensation of any smell, are effluvia, or invisible particles that fly from those bodies to our olfactory nerves. How do you prove this, says Wilson? Had you been here yesterday, you would not have asked this question; for, as the wind was north-east, the effluvia from the brick-kilns were ready to suffocate us: but now the wind is turned to the south-west, you perceive no smell, because those effluvia are driven a contrary way.

The power which some bodies have of emitting these effluvia or steams, without being visibly diminished, is to me most amazing; yet that it is true we know by experience. A single grain of musk will scent a thousand rooms, and send forth these odoriferous particles for a great number of years, without being spent. Surely these particles must be extremely small; yet their minuteness is nothing when compared to the particles of light, which pervade and find their way through glass, or to the magnetic effluvia, which passes freely through metallic bodies; whereas those effluvia that produce the sensation of smelling,

ing, notwithstanding their wonderful property of scenting all places into which they are brought, and without any sensible diminution, are yet too gross to pass the membranes of a bladder; and many of them will scarcely find their way through a common white paper.

There are but few names to express the infinite number of scents that we meet with. I know of none but those of sweet, stinking, rank, musty, and sour: for so barren is our language in this respect, that the rest are expressed either by degrees of comparison, or from epithets borrowed from bodies that produce scent; which must, in many cases, be very inexpressive; for the smell of a rose, of a violet, and of musk, though all sweet, are as distinct as any scents whatever.

The next sense under our consideration is taste, the organs of which are the tongue and the palate, but principally the tongue. I must observe, that though bodies which emit light, sounds, and scents, are seen, heard, and smelt at a distance, yet no bodies can produce taste without being immediately applied to that organ; for though the meat be placed at your mouth, you know not what taste it will produce till

you

you have touched it with your tongue or palate.

Though there is an amazing variety of tastes, yet here, as in scents, we have but a few general names to express the whole: sweet, sour, bitter, harsh, smooth, and rank, are all that I can recollect; and our other ideas of taste are generally conveyed by borrowed similitudes and expressions, as those of scents. It is surprising, says a gentleman who was present, that, in this age of gluttony, our language should be so barren, as not to afford words to express those ideas which are excited by exquisite flavours! Sir, says Mrs. Mentor, you must recollect that we are indebted for our most expressive terms to the poets, who, from their poverty, have, many of them, but little skill in the science of good eating. Your remark is a satire on the national taste, replied the gentleman, and it is a reproach that so many good poets should want patronage; but if the sons of the Muses abounded more in riches, instead of sweets and sours, and such old-fashioned terms, we might have the flavour of calapash and calapee, with a long list of other dainties, each distinguished by their proper names.

Mr.

Mr. Telescope recalled their attention to the subject before them by saying, I have already taken notice of four of our senses, and am now come to the fifth and last, I mean that of the touch; which is a sense spread over the whole body, though it is more particularly the business of the hands and fingers; for by them the tangible qualities of bodies are known, since we discover by the touch of the fingers, and sometimes indeed by the touch of other parts of the body, whether things are hard, soft, rough, smooth, wet, dry, &c. But the qualities which most affect this sense are heat and cold, and which, indeed, are the great engines of nature; for, by a due temperament of those two opposite qualities most of her productions are formed.

What we call heat is occasioned by the agitation of the insensible parts of the body that produce in us that sensation; and when the parts of a body are violently agitated, we say, and indeed we feel, that body is hot; so that *that* which to our sensation is heat, in the object is nothing but motion. —Hey-day, says Wilson, what sort of philosophy is this? Take care, young gentleman, says Mrs. Mentor, or you will forfeit all pretensions to philosophy. The forfeiture is made already, says the philosopher;

sopher; Master Wilson has been bold enough to deny that which experience every day confirms for truth. If what we call heat is not motion, or occasioned by the motion of bodies, how came the mill to take fire the other day, when it was running round without a proper supply of corn? And how came your post-chariot, Madam, to fire while running down a steep hill? Consider, there was nobody with a torch under the axle-tree; but this is a part of philosophy known even to the poor ignorant Indians, who, when hunting at a great distance from home, and wanting fire to dress their meat, take a bow and a string, and rub two pieces of wood together till they produce flame. But you may see, Master Wilson, that heat is occasioned by the motion of bodies, by only rubbing this piece of smooth brass on the table—Stay, I will rub it; it must be done briskly. There, now, you will feel it hot; but cease this motion for a time, and the brass will become cold again; hence we may infer, that as heat is nothing but the insensible particles of bodies put into motion, so cold, on the contrary, is occasioned by the cessation of the motion of those particles, or their being placed in a state of rest.

But bodies appear hot or cold in proportion

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tion to the temperament of that part of the human body to which they are applied; so that what seems hot to one, may not seem so to another. This is so true, that the same body, felt by the two hands of the same man, may, at the same instant of time, appear warm to one hand and cold to the other, if with the one hand he has been rubbing any thing, while the other was kept in a state of rest; and for no other reason but because the motion of the insensible particles of that hand with which he has been rubbing, will be more brisk than the particles of the other which was at rest.

I have mentioned those objects which are peculiar to each of our senses: as light and colour to the sight; sound to the hearing; odours to the smell, &c. But there are two others, common to all the senses, which deserve our notice, and these are pleasure and pain, which the senses may receive by their own peculiar objects; for we know that a proper portion of light is pleasing, but that too much offends the eye; some sounds delight, while others are disagreeable, and grate the ear; so heat, in a moderate degree, is very pleasant, yet that heat may be so increased as to give the most intolerable pain. But these things are so familiar to every

one's

one's observation, that there is no occasion to enlarge upon them.

Now, from the ideas or conceptions formed in the mind by means of our senses, and the operations of the mind itself, are laid the foundation of the human understanding, the lowest degree of which is perception! and to conceive a right notion of this, we must distinguish the first objects of it, which are simple ideas, such as are represented by the words, red, blue, bitter, sweet, &c. from the other objects of our senses; to which we may add the internal operations of our minds, or the objects of reflection; such as are thinking, willing, &c. for all our ideas are first obtained by sensation and reflection. The mind having gained variety of simple ideas, by putting them together, forms what are called compounded or complex ideas; as those signified by the words, man, horse, marygold, windmill, &c.

The next operation of the mind (or of the understanding) in its progress to knowledge, is that of abstracting its ideas; for by abstraction they are made general; and a general idea is to be considered as separated from time and place, and lodged in the mind to represent any particular thing that is conformable to it.

Knowledge,

Knowledge, which is the highest degree of the speculative faculties, consists in the perception of the truth of affirmative or negative propositions; and this perception is either immediate or mediate. When, by comparing two ideas together in the mind, we perceive their agreement or disagreement, as, that black is not white; that the whole is bigger than a part; and that two and two are equal to four, &c. it is called immediate perception, or intuitive knowledge; and as the truth of these and the like propositions is so evident, as to be known by a simple intuition of the ideas themselves, they are also called self-evident propositions.

Mediate perception is, when the agreement or disagreement of two ideas is made known by the intervention of some other ideas. Thus, if it be affirmed that my lord's bay horse is as high as my father's, the agreement or disagreement may be seen by applying the same measure to both:—and this is called demonstration, or rational knowledge. The dimensions of any two bodies which cannot be brought together may be thus known, by the same measure being applied to them both.

But the understanding is not confined to certain truth; it also judges of probability, which consists in the likely agreement or disagreement of ideas; and the assenting to any proposition as probable, is called opinion or belief. We have now finished this course of lectures. I hope not, says Lady Caroline with some emotion! Why, Madam, returned the philosopher, we have taken a cursory view of natural bodies, and their causes and effects; which I have endeavoured to explain in such a manner, as to be intelligible at least, if not entertaining; and pray, what more did you expect? Sir, replied the young lady, I am greatly pleased with the account you have given us; and I thank you for the pains you have taken to answer the many questions with which I have troubled you. But it would have given me peculiar pleasure to have heard you recommend the duties of humanity to every creature capable of feeling; and to have strengthened your lessons by some living examples, like those of Mr. and Mrs. Loiter at the hall, who treat their horses and dogs with such tenderness; nay, she is so humane, that she feeds her parrot and favourite cat before she eats her own breakfast. No one admires humanity more than I do, observed Mrs. Mentor; but in this instance, my dear Lady Caroline, I think you mistake the estimate of the characters you mention. There is a vast inconsistency in those minds who devote an inordinate care and attention to animals of an inferior nature; and neglect what ennobles human nature to the highest pitch, the charities of life towards their fellow-creatures. Mr. and Mrs. Loiter spare neither expence nor time for the indulgence of their animal favourites: whilst he draws his large income from trafficking in Negroes, without feeling repugnance at separating husband and wife, parents and children, and forcibly tearing them from their native soil, to endure hard labour, and frequently ill treatment from their tyrannic masters, who too often forget that they are co-heirs with them of immortality; she, on the other hand, passes her time in feeding parrots, cats, and monkeys, whilst she abandons her own offspring to the care of a hireling. In order to be truly good, we must be so in every respect, "for whosoever shall keep the whole law, and yet offend in one point, he is guilty of all." Therefore, the man of real humanity founds the law of kindness on the love of God, who enjoins us to love our neighbours as ourselves. He who makes this royal law the rule of his conduct, will not transgress towards the animals; as he will consider them, though inferior in rank to rational creatures, yet as members of the great family of the Universal Parent, who cares for all, and has with such consummate wisdom provided for the wants of the meanest of his creatures. Let the book of nature teach us to adore his providence; to bless his goodness; and to receive the numerous favours he has bestowed upon us, in our exalted scale in the creation, with thankfulness.

Mrs Mentor, on the conclusion of this speech, thanked Mr. Telescope, in the name of the company, for the instruction and entertainment they had received. The time of separation was now arrived; each returned to their respective homes, improved by, and delighted with, their visit.

APPENDIX,

CONTAINING

A List of the Optical and Philosophical Instruments mentioned in this Book;

AND

A DESCRIPTION OF

INSTRUMENTS FOR DRAWING,

WHICH WILL BE FOUND

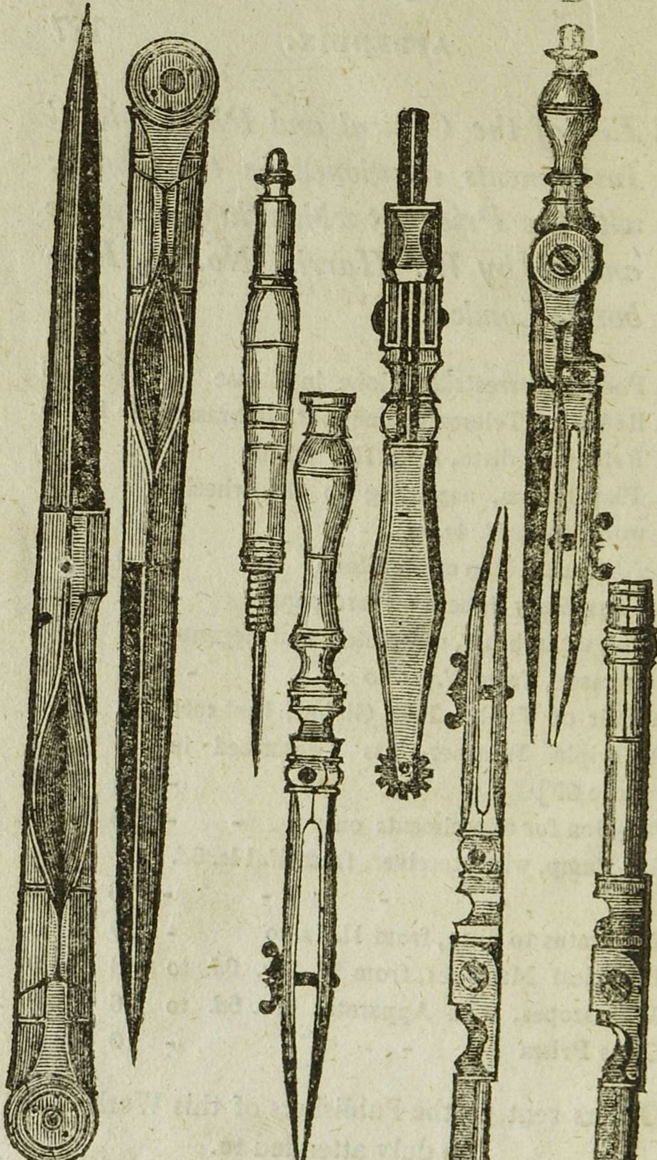
PARTICULARLY USEFUL TO YOUNG PERSONS.

A List of the Optical and Philosophical Instruments mentioned in this Book; with the Prices at which they are made and sold by W. Harris, No. 47, Holborn, London.

	L.	S.	D.
A Pocket Terrestrial Globe in a case	0	8	6
A Reflecting Telescope, one foot, in brass	6	16	6
A Refracting ditto, from 10s. 6d. to -	3	3	0
A Planetarium, according to the wheel-work, from 1*l*. 4*s*. to - - -	10	10	0
An Accurate Map of the Moon - -	0	1	0
An Armillary Sphere on card paper -	0	5	0
Ditto, all in brass, completely and elegantly made, from 3*l*. 3*s*. to - - -	12	12	0
A Pair of Twelve Inch Globes, best sort	3	13	6
A Triple Weather-glass [described in page 39] - - -	3	13	6
Air-Gun for experiments only - -	16	16	0
Air-Pump, with Receiver, from 4*l*. 14*s*. 6*d*. to - - - -	6	6	0
Apparatus to ditto, from 1*l*. 1*s*. to -	10	10	0
Electrical Machines, from 2*l* 12*s*. 6*d*. to	8	8	0
Microscopes, with Apparatus 10*s*. 6*d*. to	6	6	0
Glass Prism - - -	0	10	6

Orders sent to the Publishers of this Work, will be duly attended to.

B d c D

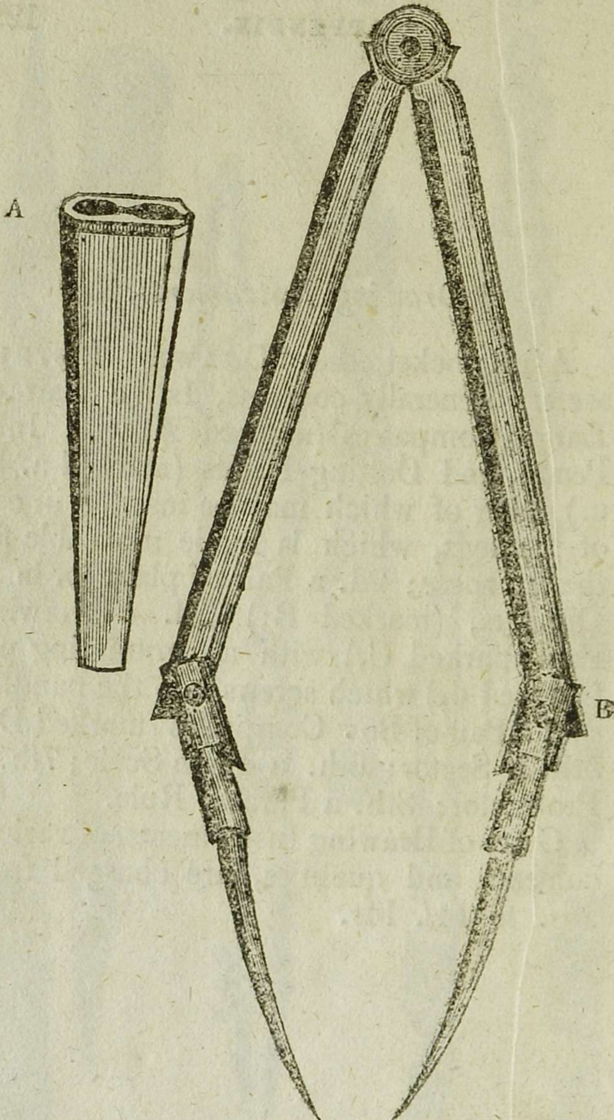


A C a b

Drawing Instruments.

A full pocket case of DRAWING INSTRUMENTS generally contains, 1st. a Pair of Large Compasses (marked A) with Ink, Pencil, and Dotting Points (marked a. b. c.) either of which may be inserted in one of the legs, which is made moveable for that purpose; 2d. a Pair of plain (or hair) Dividers, (marked B;) 3d. a Drawing Pen (marked C,) with a protracting pin (marked d,) which screws into the handle; 4th. a Pair of Bow Compasses (marked D;) 5th. a Sector; 6th. a Plain Scale; 7th. a Protractor; 8th. a Parallel Rule.

Cases of Drawing Instruments, of various contents and qualities, are charged from 18*s*. to 14*l*. 14*s*.


A
B
C
C

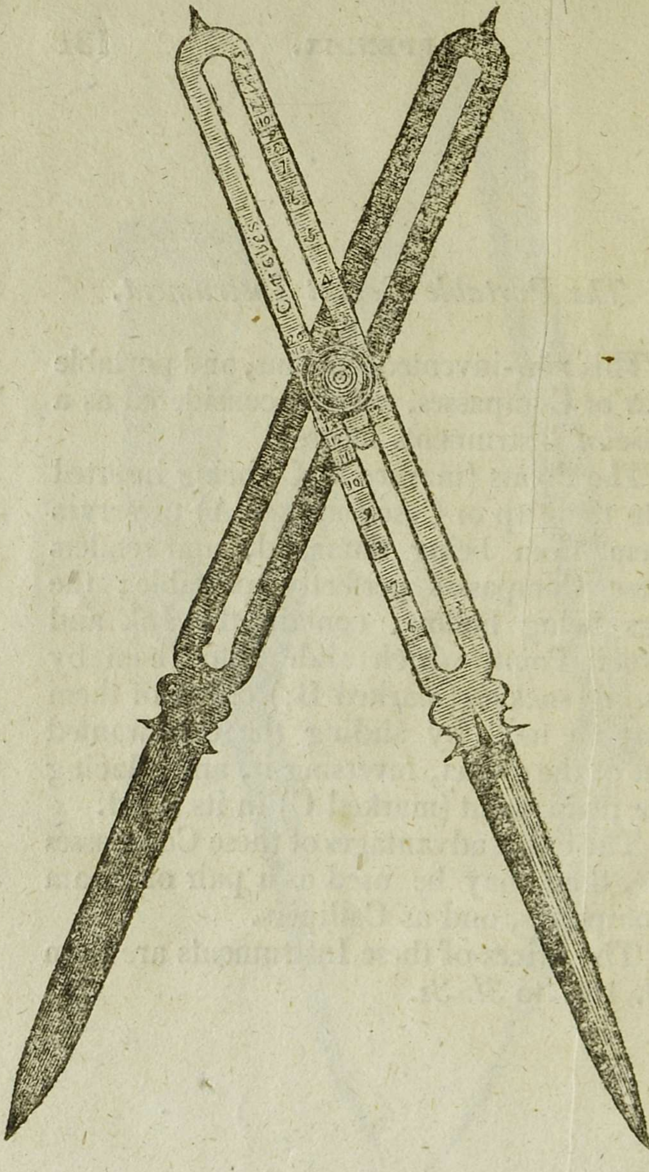
The Portable Pocket Instrument.

This new-invented, curious, and portable pair of Compasses, may be considered as a Case of Instruments in itself.

The Points (marked C C) being inserted into the Cap or Case (marked A) preserves them from being damaged, and renders these Compasses perfectly portable; the legs being hollow, contain the Ink and Pencil Point, which slide into them by spring sockets (marked B;) either of them may be used, by sliding the one wanted out of the socket, reversing it, and placing the plain point (marked C) in its stead.

The extra advantages of these Compasses are, they may be used as a pair of Beam Compasses, and as Callipers.

The prices of these Instruments are from 1*l*. 16*s*. to 3*l*. 3*s*.


Circles

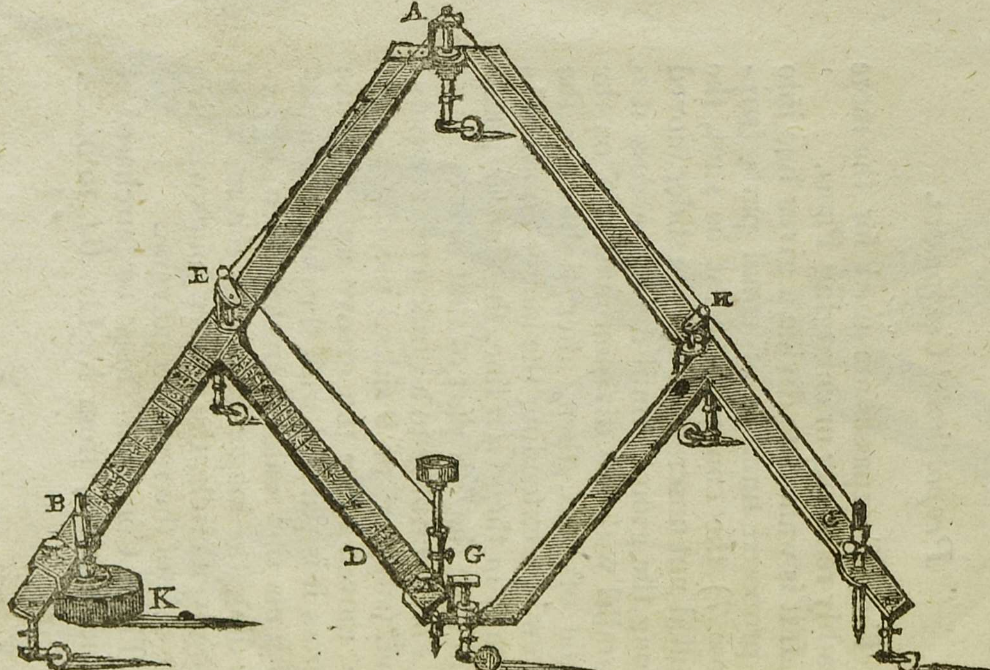
Proportional Compasses.

These Compasses are used for the more readily reducing or enlarging Plans.

If it is wanted to divide a given line into a proposed number of equal parts (suppose 7) the compasses must be shut, the milled nut unscrewed, and the slider moved along the groove, until the line across it is parallel with the division marked 7 on the scale of lines, then, after tightening the screw, by extending the longer points so as to take in the given line, the shorter points will give the 7th part of that line.

For inscribing in a circle a regular polygon, (suppose of 9 sides,) the slider must be moved along the groove until the line across it is parallel with the division marked 9 on the scale of circles; then, by extending the longer points to the radius of the given circle, the shorter points will give the side of the required polygon.

These Compasses may be purchased at various prices, from 1*l.* 11*s.* 6*d.* to 5*l.* 5*s.*


A
E
H
B
D
G
K

The Pentagraph.

The use of this Instrument is for copying any proposed Plan, Picture, Draught, &c. in any given proportion greater or less than the original.

In using it for reducing a Plan, &c. (suppose $\frac{1}{2}$) the sliders on the bars B and D must be moved to the division marked $\frac{1}{2}$, and the weight placed at B, the Plan which is to be reduced being then put under the tracing point or tracer C, the pencil at D will draw it in the proportion of $\frac{1}{2}$ to the original.

For enlarging a Plan (suppose $\frac{1}{2}$) the same method is used, except changing the situation of the tracer and pencil, placing the former at D and the latter at C.

For copying a plan of the same size, the sliders must be moved on the bars B and D to the divisions marked $\frac{1}{2}$, the weight placed at D, the tracer at B, and the pencil at C.

For striking an Oval, the slider on the bar B, must be moved to the division marked $\frac{1}{2}$, the weight placed at C, the tracer at C, and the pencil at D, then, by moving the slider on the bar D to any of the

the divisions, an Oval, more or less acute, may be struck.

For preventing the pencil making any improper marks, a string for lifting it up communicates through E A and H to the tracer.

Pentagraphs vary in prices, according to the materials of which they are made, from 24*s*. to 7*l*. 7*s*.

THE END.

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