THE

ELEMENTS OF ASTRONOMY

Adapted for the Study of Youth,

BY

SAMUEL CHAUNTLER.

REVISED BY G. ALEXANDER, Esq., M.A., Advocate.

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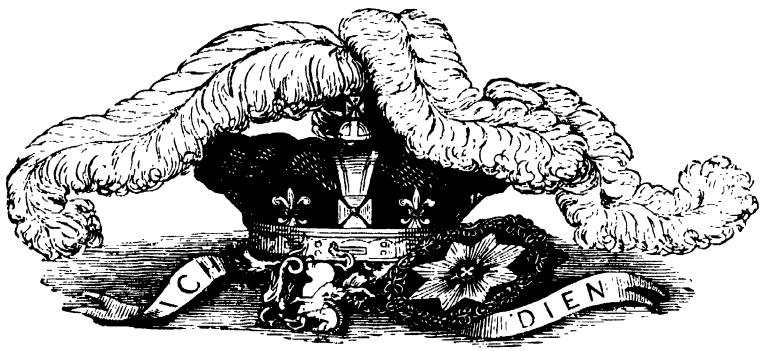


TO ENGLAND'S HOPE,

HIS ROYAL HIGHNESS, ALBERT, PRINCE OF WALES

EMBOLDENED BY THE EARLY PROMISE THAT HE WILL BE EMINENTLY THE GENEROUS PATRON OF ALL THAT CAN REDOUND TO THE GLORY OF HIS COUNTRY,

THROUGH THE INTELLECTUAL ELEVATION OF THE PEOPLE,

ESPECIALLY OF THE RISING GENERATION,

THE COMPATRIOTS OF THE HEIR APPARENT TO THE BRITISH THRONE, AND IT IS FONDLY ANTICIPATED, THEIR FUTURE SAILOR KING,

This small book of Astronomy,

THE MOST STUPENDOUS SCIENCE AND AWAKENING STUDY KNOWN TO MAN WITHIN THE REALMS OF THE MATERIAL UNIVERSE,

IS HUMBLY DEDICATED,

BY

THE AUTHOR.

ELEMENTS OF ASTRONOMY.

ASTRONOMY is a ter made up from two Gree words signifying *a sta* and *a law.* It is th science which treats c the laws observed by th stars in the heavens. B an extension of mean ing, it embraces every thing that is know about the nature and constitution, as well as about th motions of the heavenly bodies, their periods, eclipses magnitudes, distances, their diversified phenomena and the grand designs they are intended to fulfil i the vast system of the Universe.

Astronomy, in common with most sciences in thei infancy, was first studied in order to serve the pur- poses of social life. Some knowledge of the motions of the heavenly bodies is needful in every condition

of human existence. Even in the rudest state, mankind found it necessary to mark the progress of the seasons, that they might regulate the labours of husbandry, as also the migrations of the shepherd. It was needful, likewise, for the record of past events to pay attention to the aspects and movements of these orbs, for the appointment of public meetings, and for many other ordinary purposes. Accordingly, Astronomy has been found in different degrees of advancement throughout the world, and in all ages.

No subject in physical science has supplied matter so interesting to the contemplative mind of man, as the structure of the Universe; and no study is more pleasing than that which searches into the means employed by the Almighty Creator, in his admirable plan of Providence, for perpetuating the motions of the heavenly bodies, and at the same time for affording subsistence to every species of created beings, however numerous or however various. It is of importance that we be not only persuaded that God created the heavenly bodies for wise and benevolent purposes, but that we have a knowledge of the beautifully simple means made use of to produce the periodical order of day and night, summer and winter, spring and autumn, on which the changes of temperature and the succession of crops are dependent. Every one ought to understand that the genial rays

of the sun are variously distributed over the surface of our globe, which is destined for man's temporary habitation; and to acknowledge that Divine beauty which is so manifest in thus making the different climates co-operate in the production of food for the support of all and every kind of its inhabitants.

There is on the part of all people, and of the young especially, a desire to possess knowledge on the subject of this little book, of a more ardent character than what is felt and expressed towards anything else that is material which can occupy the mind. There is a feeling of immortality even in the simplest contemplation of those stupendous works of the Creator, —the heavenly bodies. And though there be a wide gulf between our practical knowledge of earthly things and our acquaintance with the celestial system, there is still great aptitude as well as desire for passing this gulf; so that the most slender bridge, so to speak, suffices to carry the delighted reader across. There is here, indeed, an uplifting of the mind, in consequence of which we contemplate the motion of the planets and the solar system as being performed with less resistance and less labour than the crawling of a worm across our path.

The curiosity of the human mind is insatiable, and the mechanisms of these wonderful heavens has, in all ages, been its subject and its employment. It has

been reserved, however, for the latter times, to resolve the grand and interesting questions as to what are the lights in the heavens. The sublimest powers of philosophy have been called to the exercise, and astronomy may now be looked upon as the most certain and best established of the sciences. Splendid beyond all expression, and even beyond all imagination, as the heavens are, the science of them is now at once the simplest and most perfect of our philosophical knowledge.

It is to be borne in mind that the solar system, in which the meanest of earthly things forms a part, and claims a share of interest, has its boundary, but space has none, any more than the Creator himself. If we wing our way beyond the limits of that system,—for it has its limits,—is there nothing beyond?—do we only travel through dark and unoccupied regions? There are only the sun and five, or at most six, of the planetary orbs which are visible to the naked eye in the solar system. What, then, is that multitude of other lights which sparkle in our firmament, and fill the whole concave of heaven with innumerable splendours? The planets are all attached to the sun, as will afterwards be shown. But the other stars do not own his dominion. They do not circle around him. To all common observation, they remain immovable. Now, the first thing that strikes the contemplator, is

their immeasurable distance. If a body were projected from the sun with the velocity of a cannon ball, it would take myriads of years before it travelled that mighty interval which separates the nearest of the fixed stars from our planetary system. These are great numbers, and great calculations; and the mind feels its own impotency in attempting to grasp them, although they can be exhibited in figures, and demonstrated by the powers of the most rigid and infallible geometry. How amazing, indeed, and how soul-elevating have been the discoveries brought to light by the improved apparatus and persevering observation of a recent period!

But again, how much lies on the other side of all which the eye or the telescope hath yet made known to us, that is beyond the limits of our astronomy? The university of space, no doubt, teems with unnumbered worlds,—with spheres and creations which no human arithmetic can count. Unquestionably, though all the visible heavens were to rush into annihilation, and the besom of the Almighty's wrath were to sweep from the face of the universe those millions and millions more of suns and of systems which dwell within the grasp of our actual observation, it might, after all, be but the disappearance of a little speck, comparatively speaking, from the boundless field of created things!

We have already glanced at some of the practical

uses of the study which is directed to the science of astronomy. It is advantageous, in an eminent degree, as regards many of the affairs of civilised life. Very remarkably important is it to the mariner and navigator, towards the guiding of his ship from one port to another, helping him to avoid the innumerable rocks, banks, and shoals with some of which his barque would, in all probability, come in contact; enabling him also to ascertain the distance he has travelled from the land he has left, and how far it is to that which he has sailed for. Thus and hence it was that the vast continents of America and Australia, as well as numerous islands of the mighty ocean, were discovered; otherwise they might have remained in the same obscure condition in our day that they were before the art of navigation was cultivated, by means of the aids lent through astronomy.

It is useful for keeping our time correct; for by the aid of instruments we can tell the period of the day or night to a second. Even the wild natives of America, and those of other savage lands, mark the lapse of time by the shadows on the ground of a tree or hut; and we ourselves have known at country places in England, where there has been no clock or timepiece of any kind, the people keeping their reckonings by similar methods. We were once at a rustic dwelling where the mother told her daughter

to inform her what was the hour; and seeing the girl leave the house to do as required, we were at a loss to know how she could bring the required information, observing that there was neither a timepiece of any sort in the dwelling, nor another house within two miles of the place. Curiosity led us to follow the girl, whom we found outside carefully counting the bricks of the building, until she reached the shadow of the barn (which stood opposite) on the wall of the house. She immediately returned to her mother, saying, "It wanted one brick to five o'clock."

Astronomy is indispensable towards the making up of the information in our almanacks, which can be done by calculations to a nicety 500 years in advance of the period of such making up; or we can tell what eclipses took place 500 or thousands of years back, the length of their duration, &c.; thus demonstrating to the most ignorant that astronomers do not, in their calculations and conclusions, work at random and in the dark, but that to far greater precision than men can observe in timing their daily transactions these philosophers announce the wonderful facts referred to with infallible correctness and accuracy.

Had it not been for astronomy our superstitious fears at this day might have been the same as those which troubled our forefathers on the appearance of a comet with its fiery tail, and those other transient

appearances in the heavens called meteors—*shooting stars, globes of fire, ignes fatui, auroræ boreales*, &c. When an eclipse occurred, the ignorant in bygone days imagined that it foretold some awful event—perhaps the destruction of the world—perhaps that war, famine, or direful pestilence would ravage their country. But, thanks to the advancement of science, this generation is better informed; and as we proceed through the pages of the present small volume, it will be learnt that an eclipse is the result of natural causes, and that there is nothing to fear from such a phenomenon, as if it were an uncontrolled or incontrollable visitant, but that they are each and every one in the hand of the Almighty, who "causeth all things to work together for good."

In truth, the natural and proper result, as well as the greatest end that can be contemplated from the study of astronomy is, the exaltation of our thoughts relative to our Creator. We are not to remain content with having merely attained a knowledge of the names and circumstances of a few planets, stars, and constellations, but we are to consider the solar system and the whole of the "starry firmament," as displaying to our view so many wonderful testimonies to the wisdom, power, and goodness of the Great Architect of the universe, and as marvellously fitted to incite us to adore, to obey, and to love Him.

"Of all the great and glorious attributes of the Being whom we worship," says Paley, "whose we are, and on whom we depend, none is so endearing, or so important to us, as his *Goodness;* that magnificent power which laid the foundation of the earth, which spread abroad the heavens as a curtain, which assigns for the sea its channels and its bounds, saying it should not pass them; who hath brought into being ten thousand worlds like our own, rolling in the firmament, all of which are put in motion and sustained in their orbs by his Almighty hand; that consummate wisdom which created universal nature, which drew such regularity as this out of chaos and confusion; which contrives with such exquisite skill the largest as well as the least part of the creation—from globes of unmeasureable magnitude down to the limbs of insects too small for our eyes to see."

Ideas similar to those of Paley are inculcated by Addison's beautiful hymn, which all those who wish to "remember their Creator in the days of their youth" will do well to repeat in their hearts, as often as they turn their attention to astronomy.

"The spacious firmament on high,
With all the blue ethereal sky,
And spangled heav'ns a shining frame,
Their great Original proclaim," &c. &c.

The poets, indeed, have striven to describe and

celebrate the wonders of the skies. Thomson thus exclaims :—

> "With what an awful world-revolving power
> Were first th' unwieldy planets launch'd along,
> Th' illimitable void ! Thus to remain
> Amid the flux of many thousand years,
> That oft have swept the toiling race of men
> And all their laboured monuments away ;
> Firm, unremitting, matchless in their course ;
> To the kind temper'd change of night and day,
> And of the seasons ever stealing round,
> Minutely faithful."

The tendency of the study of astronomy is what should most particularly engage the attention of the inquirer, seeing that it most powerfully guides the mind to interesting and sublime trains of thought, affording scope for the noblest energies of the human intellect. To what conceptions of the Creator does a serious contemplation of the heavens open to the mental eye ! and with what an intimate relationship does the science of astronomy connect itself with religion ! How often and forcibly do the Sacred Scriptures direct us to the evidences furnished by the heavenly bodies of a self-existent and eternal Being ! "Lift up thine eyes on high, and behold who hath created these things ? The everlasting God, the Lord, the creator of the ends of the earth, who fainteth not, neither is weary ; there is no searching of his understanding.

He brought out their host by number, and calleth them all by names : by the greatness of his might, for that he is strong in power ; not one faileth. It is he that sitteth upon the circle of the earth, and the inhabitants therefore are as grasshoppers. All nations before him are as nothing ; and they are counted to him less than nothing, and vanity." "Hearken unto this, O Job : stand still, and consider the wondrous works of God." Every person is bound in duty not only to study the facts and doctrines of Divine revelation, but the manifestations of the Almighty as displayed in the system of creation. Both are revelations of the same omnipotent and beneficent Being ; and the views as well as instructions they respectively infuse, when considered with a devout and reverent spirit, and with a fair degree of intelligence, are in perfect harmony with each other.

THE SOLAR SYSTEM.

BY the solar system is meant that collection of bodies, which includes the sun, the planets which revolve round him, their satellites, and such periodical comets as have had their return successfully predicted. In other words, the solar system consists of the sun in the centre, upwards of thirty ascertained planets, and an unknown number of bodies designated comets. The sun is both the grand centre and animating individual of the planetary system, around which all the planets revolve at different distances, and in different periods of time; and by whose attracting influence they are retained in their respective orbits. *Planet* is from a Greek word, signifying *I wander*, because the ancients thought that the luminaries known by that name were constantly shifting their places with reference to the other lights of the sky. We know now positively,

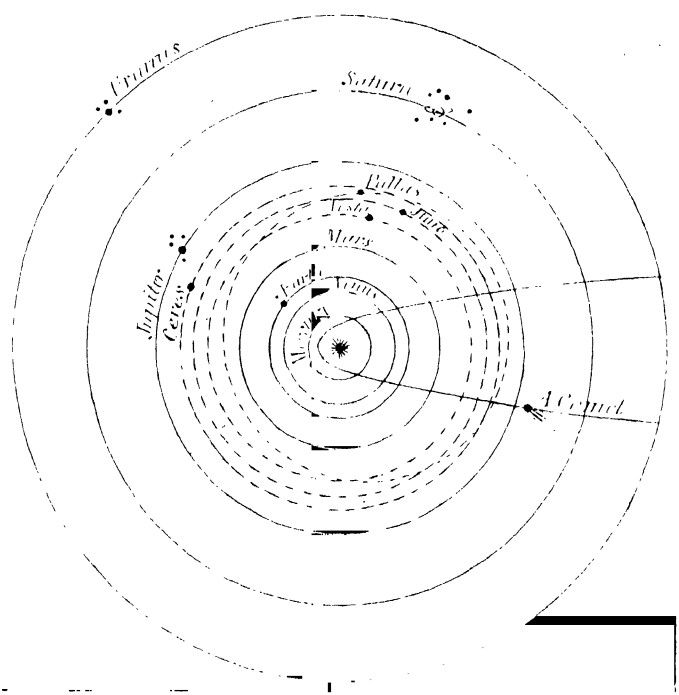
however, that they are not only retained in their respective places by the attraction of the sun, but that from this luminary they all derive light and heat, and every other influence, probably, requisite to fit them for being habitable worlds.

There are ten orbs of this description which have been traced in the heavens, and whose motions have been accurately ascertained. Five of these bodies are visible to the naked eye: the others can be seen only by means of telescopes. The five visible to the unassisted eye were known to the ancients, who gave to them these names: Mercury, Venus, Mars, Jupiter, and Saturn. The other five have been discovered by means of the telescope within the last three half centuries, and are named, Vesta, Juno, Ceres, Pallas, and Uranus. There are a number of smaller globes belonging to the solar system, which are called secondaries, or satellites, because they move round certain of what are denominated primaries, forming one grand and harmonious whole, with which we who dwell on the earth are intimately connected.

The planets move round the sun on nearly one level or plane, corresponding with the centre of his body, and in one direction from west to east. The secondary planets also move in planes round the centres of their primaries, and in the same direction, from west to east; thus performing revolutionary motions,

which are double in the case of these satellites, inasmuch as they have at once a revolution round the primary, and a revolution in company with the primary round the sun. The path described by a planet in its revolution is called its *orbit*. But, besides this motion, each planet, and even the sun, has a motion in its own body, as if upon an axis, like the rotatory motion of a wheel upon its axle; the motion on these *axes* being in the same direction as the revolutionary or orbitual movements, from west to east.

It is of this solar system that we have now to take



a rapid view. But, before proceeding further with description, it will be useful to examine the small map or diagram given on the preceding page, and to mark its different parts and lines.

The small star-like figure in the centre represents the sun. The first light circle round the sun is the orbit of the planet Mercury. The next light line represents the orbit of the planet Venus. Then comes the Earth, on which we live. Then Mars, Vesta, Juno, Ceres, and Pallas; these last four, being small planets, are called the asteroids. Beyond these, the next circle represents the orbit of Jupiter, with his satellites; and next again, the orbit of Saturn. The outermost circle is that of Uranus, sometimes called by the names of Herschel and the Georgium Sidus. True, these orbits appear very small, as shown in the diagram. They are, however, so immensely large, that the imagination reels when endeavouring to form any adequate notion of them; for the orbit of Mercury, which is the smallest, is more than two hundred and thirty-two millions of miles in circumference; while the orbit of Uranus, the most distant planet of the engraving, is eleven thousand three hundred millions of miles in circumference. The course or direction of a comet crossing the orbits of the planets is also indicated in the diagram.

THE SUN.

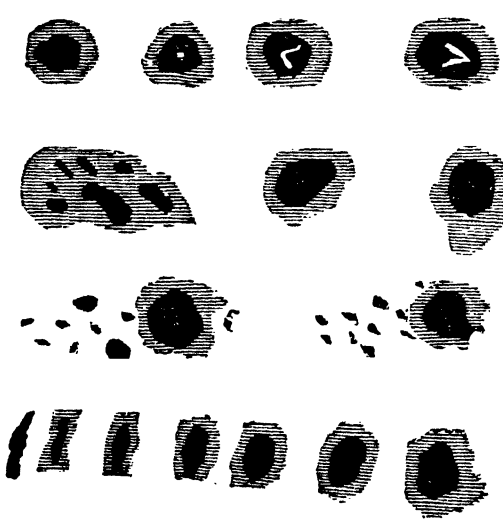
THE sun claims our first attention, because it is the centre of our system, and therefore, next to our own globe, is to us the most important object in the universe. It is a luminary found by the most accurate observations to be wonderfully larger than the earth. It has been calculated by Sir John Herschel that the sun is about ninety-five millions of miles distant from our globe. The same authority declares it to have a real diameter of 882,000 miles; thus exceeding the earth in linear magnitude in the proportion of $111\frac{1}{2}$ to 1, and in bulk in that of 1,384,472 to 1. If, in fact, the sun be formed of materials not very much rarer than the component parts of our globe, the quantity of matter in the central orb must far exceed the entire masses in all the planets

put together; and were it moved out of its place, not only the earth but all the other planets, if they were united in one mass, would, according to the laws of attraction, be carried along with it as a pebble would be with a millstone.

The sun turns round on its axis, by a motion of its own, in about twenty-five days. To explain familiarly what is meant by turning round or revolving on an axis, put a piece of straight wire through the centre of an orange, and hold the wire steadily while you turn the orange quite round upon it. The orange may represent any globe, and the wire will then be the axis. Still, you are not to imagine that the earth or any of the members of the solar system has a real axis like the wire to move upon; the *axis* is merely an imaginary line. A ball twirled and thrown from your hand into the air, revolving upon such a line, at the same time that it moves forward, affords an illustration; the two points on the surface of the ball, where this imaginary line ends, being called the poles.

The sun was supposed by the ancients to consist of pure fire; but, in modern times, and since the invention of the telescope, our knowledge of its constitution has been somewhat enlarged. Of the real nature of the luminary, however, we have hitherto acquired but very imperfect conceptions. Some astronomers are of opinion that it consists of a dark body, and that

it is not the body of matter itself which produces so much heat and light, but that these proceed from the atmosphere which surrounds it. Indeed, there seems to be now no doubt of the fact of the sun's being surrounded, to a great distance, by a faint light or luminous matter of extreme thinness, shaped like a magnifying-glass, the body of the sun being in the centre, and the luminous matter extending in the plane of the planetary revolutions till it terminates in a point. We now also view the sun itself as a solid body, composed of different materials, in which wonderful processes are going forward on an immense scale, for preparing and perpetuating the light and heat which are destined to benefit the surrounding planets. When the luminary is viewed through a powerful telescope, spots of various kinds are perceived upon its surface. Our woodcut figures may convey some idea of the phenomena. The spots, generally speaking,



resemble a dark nucleus, surrounded with a penumbra, or belt of a lighter shade, which is, for the most part, of a form nearly agreeing with that of the dark nucleus. In some instances a bright figure is to be discovered in the midst of the dark nucleus. Certain of these spots were found to be, upon minute calculation, not less than forty-five thousand miles from one extremity of them to the other. Some suppose these spots to be openings in the luminous atmosphere, and that the dark appearances are the body of the sun. It has also been observed that the spots do not remain constantly in the same place, but move regularly from one side of the sun's face to the other, and after disappearing for a time are again seen at the point from which they set out. They may be regarded, perhaps, with greatest probability, as the ridges of immense waves in the luminous region of the sun's atmosphere, indicative of violent agitation in their neighbourhood. They are often formed gradually and dissolved gradually, while those that arise suddenly are for the most part dissolved suddenly. After all, however, great uncertainty remains with regard to the nature of the spots.

Whatever opinion may be formed as to the real nature and constitution of the sun, the temperature of its visible surface cannot be otherwise than very high and elevated; much more so, indeed, than any

artificial heat produced in our furnaces, or even by our chemical and galvanic processes.

Either directly or indirectly, it has been well observed, the sun's rays are the cause of almost every motion which takes place on the surface of our globe. The sun's heat produces those currents of air called winds ; and, by the vivifying action of its rays, vegetables are called into being. By these rays too, the waters of the sea are made to circulate in vapour through the air, and irrigate the land, producing springs and rivers.

The great mystery, says Sir John Herschel, connected with the sun, is to conceive how so enormous a conflagration,—if such it be,—can be kept up. Every discovery in chemical science here leaves us completely at a loss; or rather seems to remove further the prospect of probable explanation. He, at the same time, hazards the conjecture that we should look rather to the known possibility of an indefinite generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of fuel, whether solid or gaseous, for the origin of the solar rays of heat and light. According to this conjecture the sun is the *cause* rather than the *fountain* of light and heat.

The magnificent sun is not only the grand source of light, heat, and colour to this earth, and the cause

of almost every motion which takes place on our globe, but of similar effects and phenomena imparted to every one of the planetary orbs which belong to our system, with their rings and satellites. The energy and influence of this mighty luminary cheer, warm, and animate a retinue of vast worlds, directing their motions, and preserving them all in the paths prescribed them. It is the central bond which unites the moon to the earth, and all the other planets, with their secondaries, as before said, in one grand and harmonious system. Who can reflect on the grandeur, magnitude, and *beneficent influences* of this ruling luminary, without having thoughts transported to Him who at first launched the orb from His creative arm, and still sustains it in all its energies? Oh! let us "give thanks unto the Lord—to Him who made great lights —the sun to rule the day: for his mercy endureth for ever."

We have been speaking of the sun as being a globular body; and yet it seems merely a flat circle. But this flat and level appearance arises merely from the fact of its great remoteness from us. Indeed, one could not say that an orange seen for the first time at a distance in the window of a fruit shop, was other than a flat instead of a globular object.

The sun appears to make a daily progress round the earth; but this is not the fact. You will say,

"Do we not see him rise every morning in the east, and gradually ascend until he attains his greatest height in the south about twelve o'clock, and then gradually descend towards the west, where, in the evening, he sets, or sinks beneath the earth?" Now, it is very true, that we do see what is equivalent to all this; but the very same appearances would take place were the sun, instead of taking this immense daily journey,—at the wonderful distance it is from us,—to remain at rest, and the earth merely to turn itself round on its axis once in twenty-four hours; and this is really the fact. In short, nothing is more certain in the whole range of science or of demonstrable truths than that the real motions as well as forms of the heavenly bodies are, in many respects, very different from what they appear to the naked eye, or to the mind of a person who has never turned his attention to the laws which regulate the phenomena of the solar system. It requires, indeed, a very little study of the simplest facts of astronomy to correct these vulgar notions, and wonderfully to exalt our views of the wisdom, power, and beneficence of the Creator.

THE PLANETS.

HAVING given some description of the sun, the centre and controller of the planetary spheres, the next thing to be done is to present brief and plain notices of these revolving spheres, beginning with that which is nearest to the sun, and proceeding, in order, to those which are more distant. The planets, we have already said, have all a motion from west to east round the central orb, on a plane, as represented in a diagram of the solar system, introduced above; and each revolution round the sun will be one year to the inhabitants of the particular planet; some completing that journey or circuit in less time than the earth; others taking a much longer period, as will be explained in the proper places. That the planets do revolve on their

axes, has been proved by the regular appearance and disappearance of spots on their surface, which may be seen with a good telescope; and from the planets themselves appearing to us sometimes to move forward, sometimes to be stationary, and at other times to move backwards, it is equally certain that they must travel round the sun in the same manner that the earth does.

Let a remark here be offered: In teaching astronomy, one of the most difficult points is to convey to the learner a clear knowledge of the relations of the several circles, angles, and degrees on a spherical surface; yet, unless acquainted with these, his progress will be constantly impeded by insuperable obstacles. Neither is it very easy to acquire a satisfactory idea of such relations from figures drawn on a plane surface. Hence every learner will find much advantage in using the artificial globe freely, and in making himself at the outset so familiar with its several parts and the effects of its motions, as to be able to follow them quickly in imagination.

However limited may be the spaces occupied and traversed by the sun and his attendant planets, with their satellites, when considered as portions of the universe, and as individual orbs launched into infinitude, yet these bodies and their orbits are so large, we repeat, that the human mind fails when

endeavouring to form anything approaching an adequate notion of them. Indeed, had we no other astronomical objects to contemplate, and were our knowledge and reasonings confined entirely to the solar system, we should be forced to exclaim that the works of the Divine Being are conducted on a scale of sublimity and magnificence, incomprehensible by mortals, and corresponding with the infinite power and grandeur of Him "who stretched out the heavens by his understanding."

MERCURY.

HIS is the nearest planet to the sun yet discovered, and is comparatively a small star. Its diameter is about 3200 miles, its circumference 10,053, and its distance from the sun 37,000,000 miles. It rotates upon its axis in 24 hours, 5 minutes, and a few seconds; and completes its course round the sun in 87 days, 23 hours, and 25 minutes, moving in its orbit at the rate of 30 miles in a second, 1800 in a minute. In point of fact, it is the swiftest moving planet yet known in the solar system, its name signifying "the swift messenger."

Mercury, being so near the central luminary of our system, can only be seen by the naked eye for a short time after or before sunset, and then only under the

most favourable circumstances. It emits a very bright white light, but, being so near to the sun, it is lost amid the more brilliant and powerful rays. It occasionally passes directly between the earth and the great central orb, appearing then as a black spot traversing the sun's surface. This is termed a *transit* of Mercury over the sun's disc, being a rare occurrence, at intervals of 6, 7, 13, 46, and 263 years. The reason of this phenomenon being so rare, is, that the plane of the orbit of Mercury does not coincide with that of the earth. As seen through a telescope, this planet does not always appear of the same size or form, having phases like the moon,—sometimes horned, sometimes full, because we can only see that part which is illuminated by the sun.

At Mercury the sun will present a diameter about three times greater than at the earth, and it will receive about seven times as much of the influence which, emanating from the central orb, gives rise to the phenomena of light and heat. Accordingly, the heat experienced in this planet would melt iron and the other metals, unless the rays be modified in their action by the nature of the atmosphere, and the constituent elements of which the planet is composed. The density of Mercury is greater than that of any other planet of the solar system, equalling lead in

weight.* Mountains of great height have been observed on its surface; one having been calculated at $10\frac{3}{4}$ miles in height, being about eight times higher, in proportion to the bulk of the planet, than the loftiest mountains of the earth.

It is probable that Mercury, notwithstanding its comparatively diminutive size, and that though seldom seen by the inhabitants of the earth, may yet be inhabited by sentient and intelligent beings, perhaps far superior in dignity to our race,—with constitutions fitted for that sphere. It can hardly be doubted that the material universe was created, and is still preserved in existence, chiefly for the sake of such rational natures, to afford them the means of happiness, and to give them a sensible display of the attributes of the Eternal.

* Such conclusions are deduced from the laws of gravitation, by which all the planets are directed in their motions.

VENUS.

THE most beautiful star to us in the Heavens is Venus, known by the several names of the Evening Star, Vesper, or Hesperus, from its situation being westerly after sunset; and the Morning Star, Lucifer, or Phosphorus, when it appears before sunrise in the east. It is of this planet that Milton thus speaks:—

> "Hesperus, that led
> The starry host, rode brightest, till the moon
> Rising in clouded majesty, at length,
> Apparent queen, unveil'd her peerless light,
> And o'er the dark her silver mantle threw."

Venus is the second planet in order from the sun, its orbit being between that of Mercury and that of

the earth. It is a body of about 7800 miles in diameter, that is, nearly the size of the earth, rotating on its axis in 23 hours, 21 minutes, and 19 seconds, and revolving round the sun, at the distance of 68,000,000 of miles, in 225 days, moving at the rate of 23 miles in a second. The transit of Venus over the sun's disc is a rare appearance, for the same reasons as in the case of Mercury; taking place alternately at intervals of 8 and 113 years. The last was in 1769; the next will be in 1874, and there will be another in 1882. This phenomenon is of great service in practical astronomy. It has been taken advantage of to aid in determining exactly the sun's distance from us.

The first time the telescope was directed to this planet was in the year 1610, by the celebrated Galileo, who had recently before constructed one of the first telescopes. The chief discovery he then made was, that Venus, in the course of its revolution round the sun, passed through all the phases of the moon. That the planet presents such phases to our eye is a plain proof that it does not move round the earth for its centre of motion, as the ancients thought, but round the sun, in an orbit which lies within the orbit of the earth.

Down to a comparatively late period, the greater part of the learned held the same opinion with the

vulgar, that the earth is at rest in the centre of the universe, and that all the planets revolve round it. It was objected to the Copernican system, which supposes the earth to be one of the planets, and which opinion had been lately broached,—that if this were the case, the planets Mercury and Venus would exhibit to us all the phases of the moon. This was fully admitted; but the facts could never be exhibited to the organs of human vision before the invention of the telescope.

On a fine serene evening, Galileo mounted his telescope on the tower of St. Mark, Venice, and showed to the senators of the state several of the discoveries he had made, particularly in regard to Venus, furnishing demonstrative proofs in support of the Copernican views of the universe. That night was fatal to the ancient systems of the schools; and from that date, the true system began to be recognised by the enlightened and unprejudiced, so that in the midst of every opposition it was extensively promulgated through the world.

Cassini, in 1666, discovered a small bright spot, near the section between the dark and bright side of the planet; noticing at the same time two dark oblong phenomena nearer the other side of the disc, as seen in the figure to the right of the annexed engraving. He afterwards made several important

discoveries, one of which is indicated by the figure to the left; from all of which he had plain proofs of the rotation of the planet. M. Schroeter, at a later period, discovered the twilight of Venus, or the stretching of a faint light beyond the semicircle which ought to be alone directly enlightened, as represented in the lower figure of the engraving, where the horns seem to stretch into the dark hemisphere.

Venus is believed accordingly to be surrounded by an atmosphere. Sir John Herschel conjectures, indeed, that we do not see the real surfaces either of Mercury or this other planet, as we do the moon, but only their atmospheres, much loaded with clouds,

which may serve to mitigate the otherwise intense glare of the sunshine upon them.

The sun's influence at Venus is about double of what it is at the earth. Owing to the leaning of its axis towards the plane of its orbit, there must be some striking peculiarities in the constitution of the planet. It must, for instance, have much greater diversity of seasons than we experience, and its days must be much longer where it is summer, and much shorter where it is winter, than on earth. A larger proportion, too, of the regions about its poles have perpetual day or perpetual night; while the middle or equatorial regions have two summers and two winters in each of the years. Immense mountains have been discovered on the surface of Venus, ranging, it has been said, from 12 to 22 miles in height.

The beauty of this brilliant planet has attracted particular notice in all ages, poetry having lavished upon it the sweetest descriptions and the most inviting images. It is sometimes alluded to by sacred writers, as emblematical of the Redeemer of mankind. It is called the "son of the morning," "the day star," and "the bright and morning star." Who has not eagerly, also, viewed the brilliancy of the soft soothing planet, as the sun has seemed to be dipping in the ocean? Many a time has this orb

been watched with a sort of affectionate wonder, as she pursued her serene and unmolested course, giving notice of the sun's approach in the early hour of day, and attending him to his setting in the West. Yes, she has been waited for with vigilant eyes, times without number, drawing the mind from the earth, fondly imagining that the brilliant star is inhabited by intelligent creatures, perhaps in many things resembling the human family. And yet, does not one feel fain to banish the idea that they are polluted, or the offspring of rebels to the Supreme, drawing down upon them His anger? Surely it cannot be that they are at war with their Creator, or that aught but what is pure, tranquil, and happy can be yonder. Thus would one's soul be exercised till it was found that the star was setting, knowing that it would again return to gladden the sons of men, and to exalt their thoughts of the goodness, greatness, and wisdom of God. Thus would one meditate until the spirit was forced to ask with an adoring fervour, "Lord! What is man, that thou art mindful of him; or the son of man, that thou carest for him?"

Mercury and Venus have been termed the inferior planets, as being placed within the orbit of the earth.

THE EARTH.

THE Earth is the third planet in order, and one of the smaller size, although not the smallest, having its orbit between that of Venus and that of Mars; and it is of special importance to us not only because of its being the theatre on which our race have been placed to "live, move, and have their being," but because it affords the position from which all our astronomical observations are directed, and to which all our knowledge of the heavenly bodies is brought.

In ancient times, and during the middle ages, extremely erroneous as well as defective notions prevailed regarding the size and shape of the earth. It was very generally supposed to consist of an immense plain, with the exceptions of such compara-

tively slight inequalities as diversify its surface ; that it was bounded on all sides by the sky, and that it had some extraordinary kinds of foundation infinitely downwards. Within the last 300 years, however, its true figure and dimensions have been accurately and precisely ascertained, and according to the strictest philosophical demonstration ; establishing that it is of a globular form,—that it is suspended in empty space, supported only by the invisible arm of the Almighty,—that it rotates on its own axis every day, and that it flies, like other planetary bodies, with almost inconceivable velocity round the sun every year, conveying most sublime ideas to the mind.

It is from these facts, and by the laws imposed by the Creator, that the most benevolent as well as beautiful results follow, as relate merely to the inhabitants of the earth itself. A globular figure manifestly presents the surface best adapted to a habitable world, as regards space, and also both diurnal and annual motion, affording the alternations of day and night, as we now enjoy them, together with the most equal distribution of the sun's light and heat, and of the air, as well as the mass of waters on the surface of the planet.

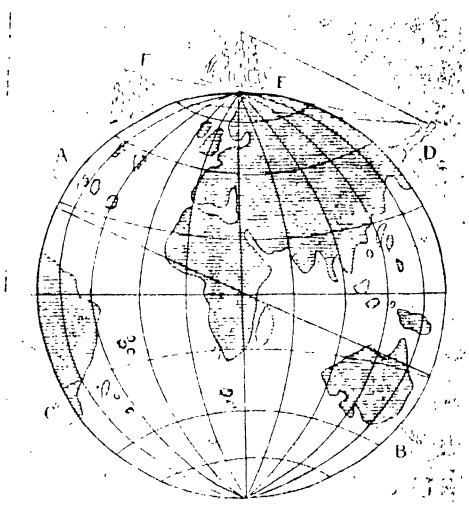
One of the most important facts in the history of human knowledge, and of the human family, is the discovery of the true figure of the earth, forming, as

it has done, the first step to momentous results, both as concerns the affairs of this world and our conception of the Almighty. Without such a discovery, continents of our globe might have remained unvisited by civilisation and Christianity for an indefinite series of ages. Without a knowledge of the true figure and dimension of our planet, we should have been without any accurate notions of the solar system, and, again, of the vastness of the material creation. Denude us of all this knowledge, and of the means or steps by which it has gradually been obtained, how mean and defective would be our conceptions of the attributes of the Creator, whose "kingdom ruleth over all." How different our views of the Eternal Divinity would be our impressions, if we regarded the earth as the centre and the chief glory of creation, denying us that perception of infinite wisdom and design, consummate harmony and beauty, which so forcibly lead us to "lift up our eyes on high, and behold the wonders of Almighty power."

The earth is now universally held by the enlightened to be round or globular, although a little flattened at what are called the poles. It is not strictly spherical, but oblately spheroidal. The following are some of the familiar evidences and proofs of its rotundity :—

Many navigators have traversed our globe's entire circumference. They have gone all this round of

many thousand miles, starting from a certain point, sailing in one direction for a number of months, and have at length reached the very same place from which they set out; a thing which could not have been, had our world been a plane, or otherwise than globular. Again: if you were to stand upon the sea-beach and observe a ship leaving England, or any other shore, you would find that the vessel gradually disappeared; the hull first sinking, as it were, into the ocean, and the rigging and masts by degrees afterwards. The convex surface of the globe may be illustrated by the representation here given. At D is stationed a person on a high tower, who has his eyes directed to the ship E; the hull and topmast are both visible at the time, nothing interrupting the straight lines of vision. Shortly, however, the vessel is at a considerably greater distance from the spectator, so that he cannot perceive the hull, on account of the convexity of the interposing



water, the topmasts being alone visible, as at F, since light passing through the same medium always flows in straight lines from every object. The other letters, A, C, B, point to little figures, which may serve to show that the lower the eye is placed, the more limited will be the view obtained. Now, do not these facts show that even the water of the mighty and expanded deep is not quite flat, or upon a perfect level, for miles and miles together? And again, in the case of an eclipse of the moon, when the earth is between the sun and that luminary, the shadow of the earth is cast upon her, and that shadow is found to be round.

In consistency with this view, the heavens are not spread above us like a canopy, or round like a dome, above our heads, with the sun, moon, and stars placed there for our use alone. On all sides of the earth there are other heavenly bodies than those which any one beholds at the same time, at great distances, round like the earth itself—the people on the opposite side of our globe to us having a sky over their heads also, and having the earth under their feet; the inhabitants, wherever situated, always seeming to be at the uppermost part. The thing which confines us to the ground, or seems to force us downward, preventing our rising from the earth, is that strong attraction, or tendency to the centre of the globe,

which acts equally on every part of its surface. Up and down are only relative terms, and may be used with equal propriety at every part of the earth's surface, or even of the universe, since in infinite space there can neither be an *up* nor a *down*.

We perceive no motions connected with our globe, but such as are produced by the rivers, the ocean, the atmosphere, subterranean concussions, and those which are the result of various artificial processes. Comparatively few persons have any conception that they are carried along through the regions of infinite space by the ball upon which they stand with the rapidity of thousands of miles every hour. Yet the fact can be as clearly demonstrated as any in the whole range of the exact sciences. The wonder that we do not feel the motion of the earth will cease in a great measure the moment it is considered how very large the globe is, and that it moves smoothly along in open space, without meeting with the slightest shock or interruption ; so that we can be no more sensible of its motion in its orbit than one would be in a boat on the canal,—the banks and trees appearing to retire from you, though in reality you are moving away from them all the while,—they being perfectly stationary in respect of you.

The mean distance of the earth from the sun is about 95,000,000 miles. Its mean diameter is about

7970 miles. It travels at the rate of 68,000 miles every hour, a motion which is 140 times swifter than that of a cannon ball; and it turns round its axis every 24 hours, from west to east, causing an apparent diurnal motion of all the heavenly bodies from east to west. It completes its revolution round the sun in about 365 days, 5 hours, and 49 minutes. As viewed from another of the planets, suppose the moon, says Dick on *Celestial Scenery*, "the earth would present a pretty, variegated, and sometimes a mottled appearance. The distinction between its seas, oceans, continents, and islands, would be clearly marked; they would appear like brighter and darker spots upon its disc. The continents would appear bright, and the ocean of a darker hue, because water absorbs the greater part of the solar light that falls upon it. The level plains (excepting, perhaps, such regions as the Arabian deserts of sands) would appear of a somewhat darker colour than the more elevated and mountainous regions, as we find to be the case on the surface of the moon. The islands would appear like small bright specks on the darker surface of the ocean; and the lakes and mediterranean seas like darker spots or broad streaks intersecting the bright parts, or the land. By its revolution round its axis, successive portions of the surface would be brought into view, and

present a different aspect from the parts which preceded."

It may here be remarked, that an opinion almost universally prevails amongst those persons who have turned their attention to the study of the planets, which serves greatly to exalt our ideas of the Deity, viz., that they are inhabited. It is thus that the eyes of Christian philosophers contemplate these orbs through the light which modern science has diffused over the wonders of creation, believing them to be the abodes of incalculable numbers of sentient and intelligent beings. The more one contemplates these heavenly bodies in this light, the more sublime and enlarged will be our conceptions of the attributes of the "high and lofty One who inhabiteth eternity," and who created and governs all the movements of the universe.

From the observations made by astronomers on the planets and their surrounding moons or satellites, it is ascertained that they are much of the same nature as that of the globe which we inhabit. True, they vary in size, and in the time they take to perform their revolutions round the sun; but in such of them as can be observed with any degree of accuracy, a regular rotation round their axis, like that of our earth, has been discovered, which causes every part of their surface to be exposed to the light and

heat of the sun, producing the regular and alternate return of day and night. Besides, mountains and valleys have been seen in the moon, which is the orb next to us; so that it is generally supposed that these characteristics exist in the other planets, as has indeed been partially made known, the effects being probably the same; the great distance at which they are removed from us alone preventing our perception of the facts. With regard to one or other of the planets, it may be said,

> "Her spots thou seest
> As clouds, and clouds may rain, and rain produce
> Fruits in her softened soil, for some to eat,
> Allotted there."

When one considers how very small the earth is, in comparison with several of the other planets,—which all appear to be blessed with similar advantages to those which we enjoy,—it is surely not unreasonable to conjecture, but quite the contrary, that instead of their being placed in the heavens merely to be gazed at by us, in their wonderfully diminished forms, especially as beheld by the naked eye, and merely to reflect to us a little of the sun's light, that they are crowded with beings as capable as we are of feeling gratitude to their Creator, and of studying his attributes.

The All-wise Being, who ordained whatever comes

to pass, has appointed the light and heat of the sun to be distributed over the surface of our globe, in a manner as most perfectly to serve the ends of beneficence. How varied are the feelings which arise in the mind, when contemplating, for example, the different seasons of the year! and yet how touching and impressive is each variety!

While the great end of the diversity of seasons is the support and maintenance of the world to which we belong, it has also an indirect tendency in the moral and religious instruction of our race. There are emotions which everywhere accompany the different seasons in a characteristic manner. When Spring appears, when the earth is covered with its tender green, and the song of happiness is heard in every shade, it is a call to us to religious hope and joy. Over the infant year the breath of heaven seems to blow with paternal softness, and the heart of man willingly participates in the gladness of awakened nature. When Summer reigns, and every element is filled with life, and the sun pursues his mighty course through the firmament above, it is the season of solemn and exalted adoration; we see then the majesty of God; and wherever we direct our eyes, the glory of the Lord seems to cover the earth as the waters cover the foundation of the great deep. When Autumn comes, and the annual miracle

of nature is complete,—when all things that exist have waited upon the God who made them, and "He hath given them food in due season," it is the appropriate period for thankfulness and praise. The season of Winter has its peculiar influences and instructions. To the thoughtful and feeling mind, it brings loud and noble lessons, such as are to be learnt amid its clouds and storms.

"Behold, fond man!
See here thy pictured life: pass some few years,
Thy flowering spring, thy summer's ardent strength,
Thy sober autumn fading into age,
And pale concluding winter comes at last,
And shuts the scene. Ah! whither now are fled
Those dreams of greatness? those unsolid hopes
Of happiness? those longings after fame?
Those restless cares? those busy bustling days?
Those gay spent festive nights? those weary thoughts
Lost between good and ill that shared thy life?
All now are vanish'd! Religion sole survives,
Immortal never-failing friend of man,
His guide to happiness on high."

The phenomena of the seasons, and the alternate succession of day and night, depend upon a few apparently simple laws or principles. But before noticing the manner in which the uniform motion of the earth upon its axis, and that in which our globe revolves round the sun, produce the wonderful and beneficent results alluded to, it is necessary to attend to some

few of those arrangements, which have been adopted by astronomers for the artificial representation of the heavens as well as of the planet we inhabit, for the purpose of mathematical demonstration, when applied to the solar system.

Every person amongst us has had his attention directed more or less to those artificial articles called *globes*, one of them giving a miniature representation of the earth, which therefore obtains the name of the *terrestrial globe*, while the other is designated the *celestial globe*, because it is intended to represent the apparent concave sphere of the heavens. With regard to the earth, astronomers have supposed certain lines to pass through and around it, with the view of facilitating the study of their science. The line from north to south, on which our globe may be imagined to turn round in the course of every 24 hours, is called the *axis;* while the two extremities, or supposed pivot-points, are designated the *poles.* A line circling the earth in the middle, between east and west, is denominated the *equator*, all to the north or south of which line being styled respectively the northern and southern hemispheres. The girth of the earth, whether between east and west, or between north and south, is divided into 360 parts, named *degrees.* At the distance of about $23\frac{1}{2}$ of these from the equator, on both sides, is a line mark-

ing the tropics,—the space between these two parallel lines being called the torrid zone, because the sun is always vertical in some part of that space, therefore a greater degree of heat is experienced than in other regions. At the distance of about $23\frac{1}{2}$ degrees from each pole is also a parallel circle, named in the one case the *arctic*, and in the other the *antarctic circle;* the spaces between the tropics and the arctic and antarctic circles being styled the *temperate*, while the spaces between these latter circles, and bordering upon the poles, are called the *frigid zones*. There is another line which cuts the equator obliquely, touching upon opposite points of the tropics, which is distinguished as the *ecliptic*. A series of lines drawn from pole to pole over the earth's surface, resembling the division lines of a peeled orange, and cutting the equator at right angles, are termed *meridians*, or lines of longitude, the word coming from *meridies* in Latin, which signifies mid-day. Only 24 of such lines are marked upon the terrestrial globe, although every spot of the earth is supposed to have one of them passing through it. At the moment when any one of these lines is opposite the sun it is then mid-day with all the places situated on that meridian, and therefore midnight with those on the other side of the earth on the opposite meridian. These circles are all divided

into 360 degrees; these degrees again into 60 equal minutes; the minutes into 60 others, called *seconds*, and so on. These arbitrary but most convenient divisions are indicated by certain signs placed at the top of the figure; thus 8° 5′ 9″ is 8 degrees, 5 minutes, and 9 seconds. A degree is 60 geographical miles, or about 69 English statute miles. The *latitude* of a place is its distance, measured according to these degrees and subdivisions, from the equator,—in north latitude or south latitude, as the case may be. There are only 360 degrees in the circumference of the earth, and the distance from the equator to either of the poles can therefore never exceed 90 degrees; while the *longitude* of a place, being the distance of its meridian from another meridian, and being reckoned from east to west, 180 must therefore be the greatest degree of longitude. Any meridian may be fixed upon from which to start—that of the Observatory at Greenwich being usually adopted for England. With the view of facilitating the measurement of latitude, each terrestrial globe has a brass meridian circle, on which are marked the degrees: while longitude is calculated by a similarly graduated circle, called the *artificial horizon*, in which the globe is suspended. The *ecliptic* is divided into twelve parts, called the *twelve signs*, which have obtained the name of the constellations through which this circle

passes in the heavens. The equator and the ecliptic girths are styled the greater circles, because they cut the globe at the thickest parts. There are smaller circles which gird the earth parallel to the equator, which are named *parallels of latitude*, because they are everywhere at the same distance from the equator, every point in any of them presenting the same latitude.

The other globe, styled the *celestial*, represents the apparent concave sphere of the heavens, or what we call the sky, in whose centre the earth appears to be suspended. It bears lines similar to those which are drawn on the terrestrial globe, each line of which is supposed to have a corresponding line to it in the heavens. Accordingly the celestial sphere has the same number of degrees as the terrestrial; while the celestial poles are in those parts of the heavens to which the terrestrial uniformly point. The celestial equator and the celestial ecliptic, correspond likewise to the terrestrial.

We now come to consider the vicissitude of day and night, and the diversified phenomena of the seasons. The earth is a globe of about 8000 miles in diameter, and turns on its axis every twenty-four hours, this being its diurnal motion. Now, owing to the situation of our globe in relation to the sun, it is impossible that more than one half of its surface, or

of any other planetary globe, can be illuminated at one and the same time; any particular place being at one time turned towards the sun, and at another away from that great fountain of light and heat. When, by the diurnal revolution, any place is averted or carried away from the sun into the dark hemisphere, it is night at that part, the light of the stars being allowed to shine upon our vision. But when any part of the earth is turned towards the sun, and into the enlightened hemisphere, it is day at that part, all the other lights in the heavens being lost in the sun's blaze and effulgence. The sun, and indeed all the other heavenly bodies, appear to move along the heavens every day from east to west. This motion, however, is only apparent, for it is caused by the earth's diurnal course, by its real motion on its axis from west to east. All the planets also, on whose surfaces spots have been discovered, are known to be globular spheres, and each one to perform rotations round its axis, so as to afford it the vicissitude of day and night, as with us, although the periods of time for this diurnal course are different; for some of the planets complete their rotation in about ten hours, and others again nearly in more than twice that number.

We have in effect said, that when any particular spot on earth comes directly opposite to the sun, it is

noon at that spot. At the same instant it is an hour before noon or mid-day at the meridian of longitude fifteen degrees to the west of the spot first supposed, and so on for every fifteen degrees farther to the west; because this difference of time is required to bring those places to be in their turn directly opposite the sun. On the other hand, it is an hour after noon for every fifteen degrees to the eastward of the spot where it is noon, because at those places the sun has already been so many hours past meridian. It is in this manner that the hour of the day is different in every part of the globe, where the longitude or meridian line is different; occasioning it to be midnight on the opposite side of the earth when it is mid-day with us, and so on with all the corresponding opposition points of our world.

The mean distance of the earth from the sun is 95,000,000 of miles, performing its annual revolution round that governing luminary in about 365 days, travelling at the rate of 68,000 miles per hour. The *mean* distance of our globe from the sun has just been mentioned; but at no time, nor in any part of its revolution, is this the exact amount, seeing that the earth's orbit is elliptical, and that the sun holds its position in respect of it nearer one end of the oval figure than the other, caused by the grand general laws of motion and gravitation, which are applicable

alike to the movements of the planets in their vast orbits, and the simplest and most ordinary changes that are continually taking place under our immediate notice. Let it be also particularly observed that the earth does not go round the sun in an upright or perpendicular manner in respect of the axis ; for this is always in an oblique or slanting position, to the amount of something more than twenty-three degrees from the perpendicular. The axis of the earth accordingly always points to the same part of the heavens in its motion round the sun. This, at first sight, appears strange, seeing that the diameter of the earth's orbit is 190,000,000 of miles. Still this number of miles forms, as it were, only a point when compared with the immense distance of the fixed stars in the heavens, the very nearest of which is at least more than two hundred thousand times farther from the earth than the earth is from the sun. In consequence of the obliquity mentioned during one part of the earth's course, the north pole is turned towards the sun, and the south is dark; and in another part of its course, the south pole is turned towards the sun, and the north is dark, which is the cause of the difference and regular succession of seasons, as will now be more particularly explained.

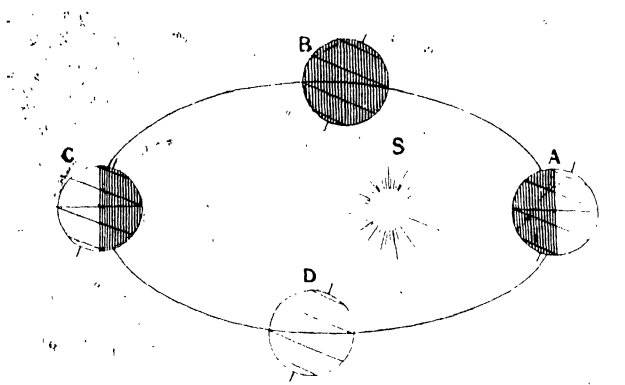
The vicissitude of the seasons is owing to the inclination of the earth's axis to the plane of its

orbit; so that in the course of the annual revolution of our globe round the sun, the inhabitants of every country, and of every clime, experience, though at different times, all the variety of the seasons, as well as the different lengths of days and nights with which they are accompanied. Spring, summer, autumn, and winter, follow each other in constant succession, diversifying the scenery of nature, and distinguishing the different periods of the year; although it is only in temperate climates that four distinct seasons are particularly marked and their more delightful diversities enjoyed. Thus it happens, for example, in Italy and the south of France; whilst in the warmest countries as well as in the coldest, there may be said to be only two seasons that materially and very decidedly differ from each other.

If a globe like that of the earth receive light from such a luminary as the sun, it is manifest that the light will fall upon half of its surface at once, while the other will be in the dark. This may be readily proved by holding any small globular object near a lamp or candle, no other light being permitted to fall upon it at the time. Still, the part or half of the globe which is thus illumined will depend upon the way in which it is held; for if perpendicularly in respect of the axis and on a level with the lamp, the

light will fall directly on the equator of the globular object, the illuminated part or hemisphere extending to each pole; and if the globe be made to turn round, it will be found that every part of it is turned towards the light during exactly half its revolution; and again, if the globe be carried in a circuit round the lamp, causing it to continue rotating all the while, the same results as to illumination will occur in every part of the supposed globe's revolution. If, however, the globe be held rather *above* the lamp than on a strict level, the under part will necessarily receive more light than the upper; and on making it revolve, one of the poles and the parts surrounding it will be continually illumined, whilst the other and its surrounding parts are constantly in shadow. If the globe be held rather *under* the lamp, the pole and its surrounding parts which before was uppermost will constantly be enlightened, while the opposite pole and its surrounding parts will be in continual darkness. Apply all this illustration to the earth's annual revolution, and it will be seen that but for the simple fact of the axis of our globe being inclined to the extent of about twenty-three and a half degrees, and the continuance of the axis in the same direction during the whole of the earth's circuit round the sun, there would be no variety of seasons; a like quantity of the light and

warmth of the governing luminary would fall upon any point of the earth's surface during the whole of its annual revolution, and the length of the days and nights would be constantly the same. In consequence, however, of the simple but wonderful arrangement which actually exists with regard to the inclination of the earth's axis to the plane of its orbit, the uniformity and monotony of the supposed state are avoided, and instead thereof we have the pleasing and most beneficial variety of spring, summer, autumn, and winter. The subject of the seasons may be still more satisfactorily illustrated by means of the following figure :—



The sun is supposed to be represented by S, and the earth at various places of its annual revolution, by A B C D. When the earth is at B or D, these are

the periods of the *equinoxes*,—a term signifying equal nights, for now it is, the days and nights are of equal length all over the globe,—the line of the equator cutting through the line of the ecliptic. But when the earth has proceeded to A,—the pole, or the axis, still keeping the same position in respect of the starry heavens,—it will be turned more directly from the sun ; a greater proportion of his rays will shine on any particular spot of the southern half of the globe, and the period of day will exceed that of darkness by the proportion of the light and shade parted in the circle of the earth. It also follows that within the circle of the south pole, the sun must shine continually, and without any intervals, for several months, to the inhabitants of that part of the globe. When the earth has reached D, one half of its annual course is completed, this being the vernal equinox. At C, again, the earth has arrived at our longest day in summer, when the axis is turned towards the sun, the regions surrounding the north pole being in perpetual light some months. The winter of the north pole is the summer of the south, and *vice versâ*. In the middle regions of our globe the sun's relative position thereto does not undergo very great changes, the heat being nearly the same throughout the entire year, and the length of the days and nights in the same regions being also nearly equal. The days and

nights are always the same length on the equator; for this line is always equally divided by the boundary between the illuminated and unilluminated halves; a fact which holds good of no other circle that can be drawn upon the earth's surface. But let it be observed that not only does the earth travel round the sun in an ellipse, but that the great governing luminary is placed nearer one end of it than the other, as shown in the above figure. It is owing to this that in our winter the earth is in the part of its orbit nearest to the sun, and that its motion is more rapid than in the summer, the interval between the autumnal and vernal equinoxes, which occur on the 21st of September and 21st of March, being nearly *eight* days shorter than that which elapses between the vernal and autumnal. Accordingly, the sun appears about one-thirtieth part larger in January than June. But is it not strange that we have the coldest weather when the sun is nearest to us, and the hottest when he is the farthest away? Various reasons, however, can be satisfactorily assigned for this apparent anomaly; the principal of these being, that the sun's rays in winter fall so obliquely upon us, and have so large a portion of the atmosphere to pass through, that they come with less force, and spread over a larger space than they do in summer, when the sun is at a greater height above the horizon.

Moreover, during the long nights of winter we have a greater amount of cold than can be compensated by the return of heat in the short days, the cold being increased till the days sensibly lengthen ; just as, on the other hand, in summer the earth and the air are heated by the sun in the day time more than they can be cooled in the night, going on increasing till the days sensibly decline.

THE MOON.

THE Moon is a satellite or secondary planet to the earth, round which it revolves, in an elliptical orbit, and with which it is carried annually round the sun. Its mean distance from the earth is about 237,000 miles. Owing to the comparative shortness of the distance between our globe and its satellite, the latter appears to us to be a large luminary, although really the smallest of all those heavenly bodies discerned by the naked eye. It also follows from its near proximity that we are better acquainted with the constitution of the moon, than with any other of the heavenly bodies. In fact, a well-constructed telescope, magnifying a thousand times (and there are instruments of a greater power than this), enables

astronomers to behold the surface of the luminary, as if they were at no more than 237 miles from it. The earth will appear at the moon *thirteen* times larger than the moon does to the earth, supplying the satellite with a proportionably more brilliant light than what it sends to us. To the moon's inhabitants the earth appears the largest body in the universe.

The moon is a globe of 2160 miles in diameter, being about a forty-ninth part of the bulk of the earth, revolving round its primary in 27 days, 7 hours, 43 minutes, and 11 seconds. It is 400 times nearer the earth than the sun is; but the diameter of the sun being about 400 times greater than that of the moon, they appear to us of nearly the same size. The moon rotates on her axis in exactly the same time as she revolves round the earth, consequently presenting at all times the same part of her surface towards the earth; so that from one half of the moon the earth is never seen at all, while from the middle of the other half it is always seen overhead, turning round about almost thirty times as quick as the moon does. We have said that the moon completes her revolution round the earth,—returning to the same place among the stars,—in about 27 days, $7\frac{3}{4}$ hours: still the interval between new moon and new moon is about 29 days, $12\frac{3}{4}$ hours. The reason of the differ-

ence is, that the time of new moon depends upon the position of the moon in regard to the sun. Supposing the sun and moon to have been in conjunction at a given time in a given part of the heavens, *she* will return to the same point in about 27 days, $7\frac{3}{4}$ hours, but *he* will have left this position, proceeding in his apparent course, so that the moon has to overtake the sun, so to speak, before being again in that position which we call new moon.

The moon, as well as all the other planets, with their satellites, receives its light from the sun. And yet the uninstructed continually speak of the moon as shining, and talk of moonlight. Hear even how old Homer describes moonlight, to which he compares the effects of the watch-fires in the Trojan camp :—

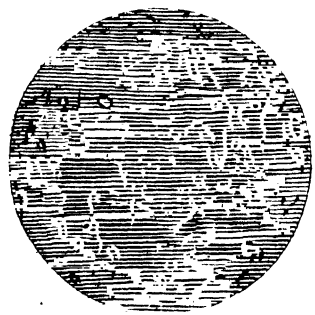
> "As when the moon, refulgent lamp of night,
> O'er heaven's clear azure spreads her sacred light;
> When not a breath disturbs the deep serene,
> And not a cloud o'ercasts the solemn scene;
> Around her throne the vivid planets roll,
> And stars unnumber'd gild the glowing pole,
> O'er the dark trees a yellow verdure shed,
> And tip with silver every mountain head.
> Then shine the vales—the rocks in prospect rise,
> A flood of glory bursts from all the skies;
> The conscious swains rejoicing in the sight,
> Eye the blue vault, and bless the useful light."

Now, all this is very beautiful, and quite true also,

according to appearance; yet it can positively be shown, that it is only the light which the moon receives from the sun, which is reflected to us from her surface. If the moon had effulgence of its own, we should not discover any more difference in her appearance at different times, than we do in the appearance of the sun.

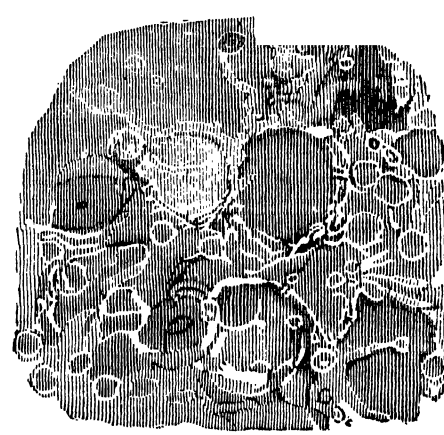
On looking at the full moon attentively, even with unaided eye, its surface presents a mottled appearance. This has been carefully examined through telescopes, and is held by astronomers to be caused by vast mountains and cavities, just like, indeed, the mountains and vallies of our earth. Maps of the moon have accordingly been constructed, presenting its elevations and hollows, some of them having been named after those philosophers who have advanced the science of astronomy. By some it is held, that a close similarity exists not only between the lunar mountains and those of our globe, but that certain of them are really volcanoes, emitting fire. An appearance of this kind was discovered a good many years ago by Ulloa, in an eclipse of the sun. It was a small bright spot like a star, near the margin of the moon, and which he at that time supposed to have been a hole with the sun's light shining through it. Succeeding observations, however, have induced astronomers to attribute appearances of this kind

to the eruption of volcanic fire; and Herschel as well as others have particularly noted several such eruptions.



Telescopic Appearance of the Moon.

Sir David Brewster has said that philosophers need scarcely despair, by means of more powerful and penetrating telescopes than have ever yet been constructed, "of discovering the structures erected by the inhabitants of the moon." The following figure represents a magnified portion of the satellite's disk, exhibiting several circular plains, cavities, and other varieties of the lunar surface, rendering it manifest that an immense diversity of picturesque and sublime scenery characterises that sphere.



Having cited Sir David Brewster's view with regard to the conquests which yet may be achieved through the aids of astronomical instruments, it may here be stated that the condition and real aspect of the moon have been largely disclosed by the telescope of Lord Rosse, serving to show that the characteristics of our satellite, as far as they are ascertained, are inconsistent with the idea of its being at present inhabited by such races of creatures as those which people the earth, and almost forbidding the hope, as some think, of its ever becoming so. No appearance of vegetable life, nor the slightest variation of surface which can fairly be ascribed to vicissitude of season, can any where be discovered on the disc of the moon. Neither are there any distinct signs of an atmosphere; and, consequently it has no clouds. Its climate must, therefore, be of a nature that is peculiar, consisting of an alternation from unmitigated and burning sunshine, continuing thus for a whole fortnight, and then abruptly changing to the keenest severity of frost, for a similar period.

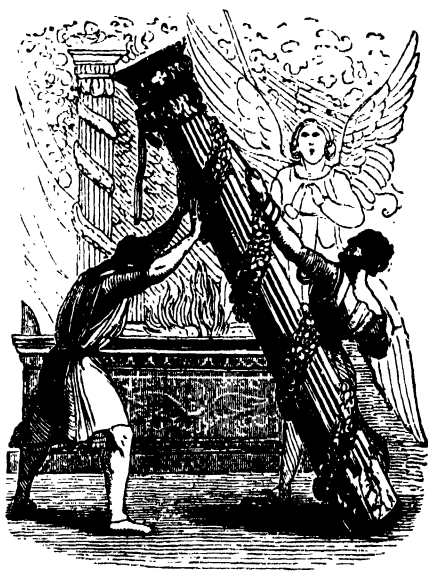
The alternation of the condition of our satellite from heat, fiercer than an equatorial noon for about a fortnight's continuance, to the intense cold of our polar regions for a similar period, is owing to the fact of the moon, during each revolution round the earth, turning exactly once round on her own axis. The

consequence of this is, that the same face is always presented to *us*, whilst different sides are successively turned towards the *sun*. The fact now mentioned has been illustrated by this simple method. Take any object, a book, a box, or an inkstand, and carry it in a circle round another; it will be found that, if no twisting motion be given to it by the hand, different sides of it will be progressively turned towards the central body; and that it will be necessary, in order to keep the *same* side towards that body, to give it a kind of twist, as it is moved round, which will, in fact, turn it once round upon its own axis during each revolution. It is to be observed, that this same twist has the effect of turning *different* sides towards any body at a distance. It is in consequence of the moon having the rotatory motion described, that her different sides are not turned, one after another, to the earth, and also that the *same* face is not consequently presented to the sun; for otherwise only the inhabitants of *that* face or hemisphere would enjoy the sun's light and warmth, instead of having the alternations of a fortnight's duration, as already noticed.

The telescopic observations made upon the surface of the moon tend strongly to uphold the hypothesis that all the bodies of space are composed of similar materials, though differently combined, and subject to

certain variations. There is another striking remark to be offered;—since matter appears to have been created chiefly in subserviency to mind, it is thought to be improbable that the Almighty would leave a globe containing a surface of 15,000,000 of square miles altogether destitute of sensitive and intellectual beings; He being able, in all cases, to adapt the inhabitant to the nature of the habitation provided for him. Or, to notice another conjecture, the moon may only be in an earlier stage of the progress through which its primary, the earth, has already passed, so as in the course of ages to be in a condition fit for the production and support of animal life.

PHASES OF THE MOON.



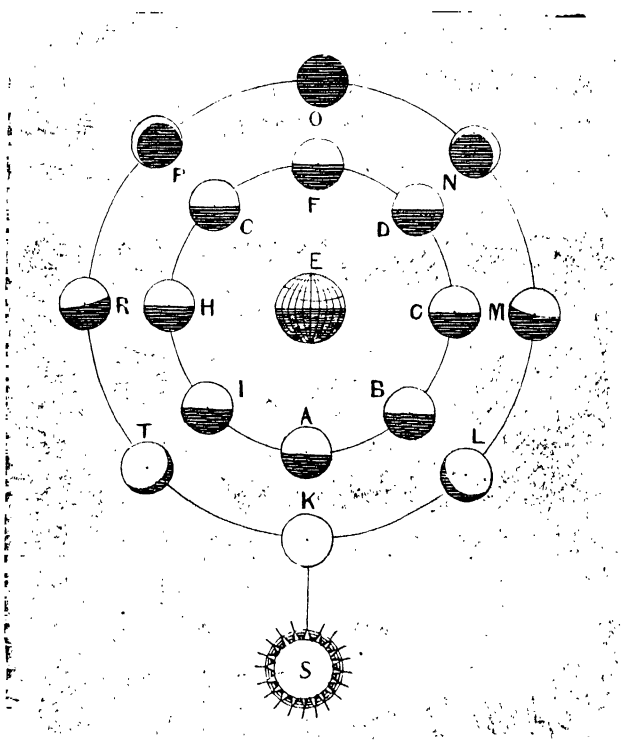
ALTHOUGH the moon, during her monthly revolution round our globe, always presents the same face towards us, and although the sun always enlightens one-half of the moon, yet it is only in one part of her orbit that the whole of this enlightened side is turned towards the earth, that side undergoing a series of remarkable changes in the degree of its illumination at different parts of the circuit, called the *Phases* of the moon. When the satellite is at the greatest distance from the sun, we, being between the two, behold the whole of the illuminated surface, which is termed *full moon.* As she advances in her course, the luminous side is gradually averted from us, and the moon is

said to wane. At length, when the satellite has got between the earth and the sun, the enlightened face is entirely lost sight of. The orb is then said to *change*. After this, proceeding in her journey, she soon turns a bright edge to us, which we call the *new* or *horned moon:*

> "Dian's bright crescent, like a silver bow
> New strung in heaven."

The bright edge gradually increases in breadth, till a moiety of the circle is quite filled up, giving us the *half moon*, and so on till it reaches full moon again. The cause of these phases can be very clearly exhibited by a diagram. Let S represent the sun, E the earth, and A B C D F G H I the moon in different parts of its circuit round the earth, with its hemisphere turned towards the sun entirely luminous. When the moon is at A, its luminous side being wholly turned away from us, the dark face must be to us, and were it then visible, it would appear as at K, in the outer circle. This is the period of new moon. When the satellite has advanced from A to B, a portion of its enlightened surface is then turned to the earth, appearing as a crescent at L; when arrived at C, the one-half of the enlightened hemisphere is turned to the earth, and it appears in the form of a half moon as at M; when at D, it presents what is termed a

gibbous phase as at N ; and when at F, it shines in all its splendour as a full moon at O. After this it gradually wanes, first to a gibbous phase again, as at P ; next to a half moon, as at R ; then to a crescent, as at T ; after which the orb arrives at its former position at A, the period of new moon ; when it is again invisible. See the engraved figure.

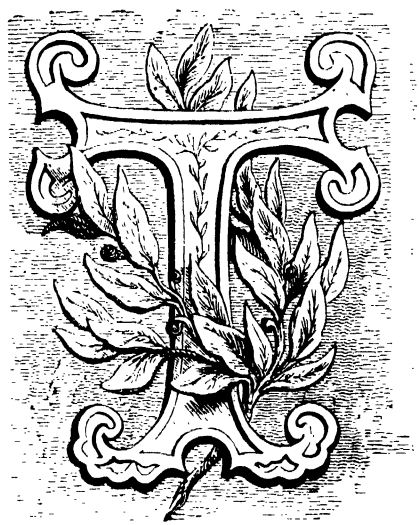


In the early days of the new moon, the dark part of the orb faintly illuminated is generally seen, an

appearance commonly known as "the old moon in the young moon's arms." This light is reflected from the earth, serving as a splendid and large moon to our satellite, and going through a corresponding series of phases; only, that when the moon is at full with us, we are invisible to the inhabitants of the moon, because our enlightened side is wholly turned away from them. In like manner, at our new moon, the earth is at full to the inhabitants of our satellite. Accordingly, the light which makes the dark part of the moon visible to us, may be characterised as that which accomplishes those journeys,—first from the sun to the earth, then from the earth to the moon,—and, lastly, from the moon back to the earth, before we are enabled to discover the phenomenon.*

* The Harvest Moon is an epithet applied to our satellite in the autumnal months, when the luminary rises on successive nights soon after sunset. This takes place during the time that it is full moon, and for a few days before and after, there being less difference in the time of her rising on any two consecutive nights than when she is full in any other month of the year; affording a most serviceable light immediately after the sun has disappeared, and displaying very strikingly the goodness and wisdom of the Creator. This phenomenon is owing to the oblique ascension of the sign of the Zodiac through which the moon is then passing, or, in other words, to her orbit being parallel to the horizon. Experiments have shown that the light of the full moon is three hundred thousand times less than that of the sun, and that it produces no heat.

MARS.



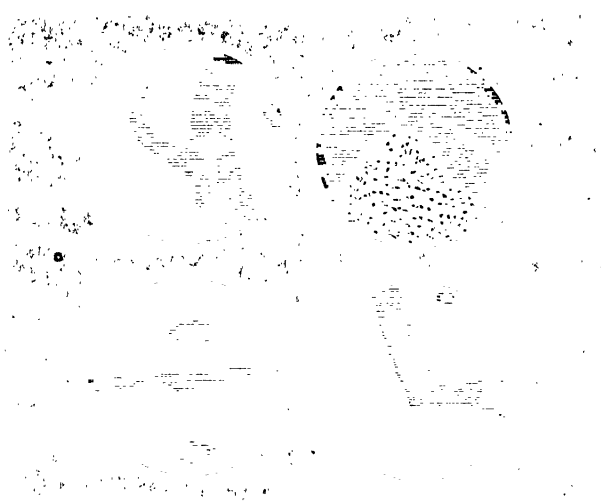
THE *inferior planets* are Mercury and Venus, being so designated because their orbits around the central luminary are included within the orbit of the earth, and consequently nearer the sun than our globe. The first of those planets, which, as their orbits include that of the earth, are termed the superior planets, is Mars. It is a globe of 4189 miles in diameter, being little more than a half of that of the earth; consequently, the bulk of this planet is only about one-fifth of that of our globe. It performs a rotation on its axis in 24 hours, and a trifle more than 39 minutes, revolving round the sun, at a mean distance of 146,000,000 of miles, in 686 days, 22 hours, and 18 seconds; his eccentricity amounting to nearly one-tenth of this, for its orbit is very elliptical. Since its orbit is

entirely beyond that of our planet, its place in the heavens is much more variable than that of the two inferior planets, which are never seen at any great distance from the sun.

Mars appears to the naked eye of a dark-red hue; and it was from this circumstance,—the resemblance to blood,—that the ancients bestowed upon it the name of the God of War. When beheld through a telescope, this planet exhibits a round disc, without, however, any well-defined indentations or projections, and, therefore, it is conjectured that there are no lofty mountains upon its surface. Still, very distinct as well as constant peculiarities of colour are observable in different parts of its disc, with outlines so decided, that they have been supposed to be the limits of continents and seas. The engraving here introduced represents Mars, as beheld through Sir J. Herschel's twenty-feet reflecting telescope. The supposed continents are distinguished by reflecting the red and fiery hue which characterises the light of this planet, this hue being thought by Sir John to be owing to the peculiar tinge of the planet's soil.

Contrasted with this, the supposed seas appear greenish.

The peculiar appearances on the surface of Mars, not being always beheld with equal distinctness, although when well seen they always present the same aspect, have led to the opinion, that the planet is not without an atmosphere and clouds. This opinion is strengthened by the appearance of brilliant white spots at the poles, which have been thought to be snow, since they vanish when they have been long exposed to the rays of the sun, and are again most strongly and vividly exhibited on emerging from the long night of a polar



winter, extending as this winter does to eleven months, the revolution of the planet round the sun taking about

one year and ten months. The woodcut in the preceding page presents three of the telescopic views which have been taken of Mars. The upper figure to the right, is one of the views taken by Sir J. Herschel with his twenty-feet reflector; the dark portions being considered to be water, and the white spaces land; the white polar spot is also indicated. The upper figure to the left, presents another of the views given by the same astronomer, showing the appearance of a portion of a sea, with a gulf running up into the land. The lower figure to the right, is a view of Mars, which has been several times observed about the time of the planet's opposition to the sun. The lower figure to the left, is a view of Jupiter given by an astronomer of the name of Maruldi, which he observed in 1704; when, by means of certain prominences, he determined the period of that planet's rotation.

All astronomers admit that an atmosphere, or body of air, of considerable extent and density, surrounds the planet Mars; seeing that small stars as they approach the edge of its disc, suffer a gradual diminution before they disappear, by the interposition of its body; and this obscuration of a star, when seen in such circumstances, must, it is concluded, arise from its being observed through a dense medium connected with the planet. The circumstance of such an atmosphere, together with the certain fact

that the planet has a revolution round its axis, so as to produce the alternations of day and night, furnishes strong presumptions that Mars is fitted for the existence of sensitive and intelligent beings. If it be environed with an atmosphere, in which clouds exist; if its surface consists of land and water; and since it must have a variety of seasons, although of much longer duration than what is experienced on earth, this planet will bear a much more striking resemblance to the world in which we breathe, than any other orb in the solar system.

At the period when this planet is nearest the earth, as also a short time before and after being in this position, it has a very splendid appearance, almost equalling the lustre of Jupiter. Indeed, according to the position in its orbit, a larger or smaller proportion of its disc will be seen. Still, the planet is never totally obscured; neither does it ever present the crescent-like appearance which is seen in Venus and Mercury. To the inhabitants of Mars, if there be any, the earth will present appearances very similar to those which Venus exhibits to us, with, however, a less brilliant light, and a smaller disc. No satellite has yet been discovered as an attendant on this planet.

THE ASTEROIDS.

THERE had been no planet discovered as existing between Mars and Jupiter, until the commencement of the present century; none, in short, which was unknown to former astronomers. The existence, however, of a planet in the interval particularly noticed, had been very confidently conjectured, chiefly because that vast extent of space is much larger than might be anticipated, as being void in the particular part of the solar system. From the interval of nearly three hundred and fifty millions of miles, which lies between the orbits of Mars and Jupiter, it was thought highly probable that some planet either existed or had existed in some tract of this amazing region, so as to present some proportion such as seemed to be established in the arrangements of the solar system, as

these were interpreted when comparing the distances which intervene between the orbits of Mercury, Venus, the Earth, and Mars. The interval between the orbits of Mercury and Venus is about half of that between the orbits of Venus and the Earth; whilst this interval, again, is about half of that between the orbits of the Earth and Mars; whereas the space between the orbits of Mars and Jupiter vastly exceeds this proportion. Hence the anticipation and expectation; nor did such conjectures remain unrealised, seeing that within the limits of the current century, four small planets, commonly known as the *Asteroids*, were discovered, whose orbits at no great distance from each other, revolve round the sun, at an average of about 100,000,000 of miles beyond the orbit of Mars, corresponding pretty closely with the presumed probability. The small size of the bodies was the cause of their so long eluding the notice of astronomers.

These four small planets revolve in paths near and crossing each other, being not only much more elliptical than the paths of the other planets, but they also rise and sink much farther from the plane of the general planetary revolutions. The first of them which happened to be observed was Ceres. This occurred at Palermo in 1801, the discoverer being Piazzi, a Sicilian; the other three were discovered

during the course of the next seven years: Pallas in 1802, by Dr. Olbers; Juno in 1803, by M. Harding of Lilianthal; and Vesta in 1807, by Dr. Olbers. The magnitudes of those four bodies being comparatively small, and the difficulty of ascertaining their diameters being great, less has been ascertained of them, than of most of the planetary spheres.

Vesta is described by astronomers as being the nearest of the four Asteroids to the sun, and was the last discovered. Its dimensions are not certainly known. According to some, the extent of its surface does not exceed that of France. It revolves round the central luminary in 3 years 66 days and 4 hours, at a mean distance of 225,000,000 of miles. Though the smallest of all the planets, it gives a very brilliant light, insomuch that it can be seen by the naked eye.

Juno is one thousand four hundred and twenty-five miles in diameter, and presents, when viewed through the telescope, a lightish hue, and well-defined appearance; and it seems to be surrounded with a dense atmosphere. Its orbit is the most eccentric of all the planetary bodies, being 253,000,000 of miles from the sun at the greatest, and only 126,000,000, or less than one-half, at the least distance.

Ceres is of a slight ruddy colour, and appears about the size of a star of the eighth magnitude. But there is great uncertainty as to its magnitude. Its

atmosphere is reckoned at about six hundred and seventy-five miles in height. It revolves round the sun, at a distance of at least 260,000,000 of miles, in 4 years 7 months and 10 days.

Pallas also presents a very indistinct appearance, when viewed with a powerful instrument; so that its diameter is equally uncertain with that of Ceres. Its mean distance from the sun is about 267,000,000 of miles; its orbit being extremely elliptical, so that its eccentricity is nearly the same with that of Juno. Its period of revolution is 4 years 7 months and 11 days.

There are several very remarkable circumstances to be noted with regard to the Asteroids. Dr. Olbers had conjectured, after the discovery of the first three, that they were merely fragments of a larger planet which had been disrupted by some internal convulsion, and that several more might yet be discovered between the orbits of Mars and Jupiter. Certain peculiarities in the revolutions of the three bodies served to strengthen his opinion, that they had all diverged from the same point. He therefore examined three times every year all the small stars in particular constellations where the other supposed fragments might most probably be expected, and at length his anticipations were so far fulfilled, and his labours crowned with success, in the discovery of a new planet, to which he gave the name of Vesta.

Prompted by such success and ever ardent in the career of discovery, as all men of science are, other astronomers have addressed themselves to the business of examining particular regions of the heavens, in the hopes of finding other planets, or supposed fragments, between the orbits of Mars and Jupiter; and so late as the year 1845, Professor Encke, of Berlin, discovered another new planet which has received the name of *Astræa*. This body was afterwards observed in England by South, Airy, and others. Even, still later, other two have been announced as belonging to the group, under the names of *Hebe* and *Iris*. *Astræa* revolves round the sun at a mean distance of 247,000,000 of miles in 1521 days.

It seems to be acknowledged by all contemporary cosmogonists that all these asteroids or small planets, are not to be considered as distinct and independent in the same degree with Mercury, Venus, and the other primaries. A variety of observed circumstances as well as theoretical views have led to the strong presumption, that the matter which had gone to form one planet of the first rank, has in the case of this group, been separated into several parts, assuming various but connected orbits.

At the first they were conjectured to be fragments of some far greater body, which formerly revolved in the orbit where it was expected, but

which had been blown to pieces, by some internal explosive force, or shattered by collision with a comet. There are anomalies and peculiarities, in the case of these lately discovered bodies, which seem strongly to suggest the occurrence of some such catastrophe, opening a field for the most interesting speculation, and also stimulating to much further inquiry. Supposing that the asteroids revolve in the state in which they were at first launched into infinite space at the *fiat* of the Almighty, then they present phenomena out of harmony with what philosophers have hitherto considered the arrangements of nature within the scope of our observation, and teach how limited are human views, and how mysterious to man are the ways of the Creator. If, on the other hand, the phenomena be the effects of some terrible explosion or dreadful collision, what may have been the fate of the beings who may have inhabited the original planet? We know that our own globe has been subject to one tremendous catastrophe since it was formed into a planetary body essentially the same as it now appears, when "the cataracts of heaven were opened, and the fountains of the great deep were broken up." We also are led to believe by the revelation of God's will and purposes, that the day is coming when the sphere which we inhabit shall be baptised with fire,—when it shall undergo a tremen-

dous change,—when its constituent parts shall be dissolved or remodelled,—when the "heavens shall pass away with a great noise, and the elements shall melt with fervent heat, the earth also, and the works that are therein shall be burned up."

Instead of the idea that the asteroids are fragments of a larger planet having been disrupted by some internal explosion, or external concussion, which conjecture Sir J. Herschel says "may serve as a specimen of the dreams in which astronomers, like other speculators, occasionally and harmlessly indulge," it has come to be more generally supposed, that the formation of these comparatively small bodies has been in accordance with the general theory of the formation of the solar system, which theory will in a later chapter be explained, viz. that of the *Nebular Hypotheses.*

JUPITER.

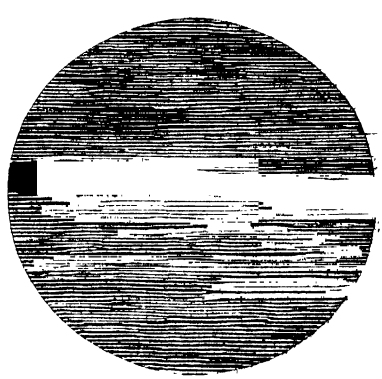
THE most magnificent and by far the largest planet attached to our system is Jupiter; next to Venus, it is the most brilliant. Its bulk exceeds that of the earth nearly 1,300 times, its diameter being 87,000 miles; and its magnificence is still further increased by the attendance of four secondary planets or satellites, which incessantly revolve around it, accompanying their primary in its annual journey round the sun, in like manner as the moon revolves about and accompanies our earth; thus forming with the mighty planet a comparatively small system, analogous to that vaster one of which their central body is itself a member. Jupiter is situated about 495 millions of

miles from the sun. When nearest the earth, it is 400 millions of miles from us, but when in the part of its circuit it is farthest removed, 590 millions of miles intervene between us and the splendid planet. Its revolution round the sun is performed in about 11 years, 10 months, and 17 days, during which period it accomplishes a journey of more than three thousand millions of miles, at the rate of above twenty-nine thousand miles an hour. Yet this huge orb moves round its axis in about nine hours and fifty-six minutes; being a more rapid motion than that of any of the other planets. Its rotation was first determined by Cassini, about the year 1665, in consequence of that astronomer having observed the gradual motion and revolution of a spot which appeared to move from one side to another of its disc, and which returned again to the same spot in something less than ten hours. Hence there must, from the planet's rotation round its axis, be an alternate succession of day and night on Jupiter, analogous to what is experienced by ourselves, although the days and nights will be much shorter than ours. The axis round which this mighty planet turns being nearly perpendicular to the plane of its orbit, the sun must always shine nearly upon its equator, so that there can be but little variation either in the seasons, or in the length of the days and

nights in different parts of its globe, and at different periods of its year. Besides, the proportion of light and heat which this planet receives from the sun, can only be about 127th part of that which comes to the earth ; so that if Jupiter be peopled with animated beings, we must conclude that their organisation and nature are very different from such living creatures as inhabit our globe.

It has already been stated that Jupiter's bulk is about 1300 times that of the earth. But it has been ascertained that the density of this enormous planet is only about a quarter that of our globe, being nearly the same as that of the sun.

The disc of Jupiter, when examined with a good telescope, always appears crossed in one certain direction by a number of bands or zones, of a darker hue than the rest of the orb. These appearances are generally termed *belts*, which, at different times, vary in breadth and in situation on the disc, though never in their general direction. These belts were first discovered



Telescopic appearance of Jupiter.

by Fontana, and two other Neapolitans, about twenty-five years after the invention of the telescope. They were afterwards, in consequence of the aids of more powerful instruments, described with greater particularity; for when a magnifying medium of above a hundred times is used, the surface of the planet appears much larger than the full moon does to the naked eye. The belts have been, as a rare phenomenon, observed to be broken up, and distributed over the whole surface of the planet; but a much more common appearance is, to find branches running out from them, with subdivisions; and dark spots are by no means extraordinary, resembling strings of clouds. From the appearance of the belts, and the observation of their being continually subject to particular changes, the conclusion has been arrived at, with considerable probability, that they are produced by variations in the atmosphere of the planet, caused by currents similar to our trade-winds, but of a much stronger and decided character, as will be readily conceived to be occasioned by the extreme velocity of the orb's rotation. That it is the darker bands and spots which belong to the body of the planet, and that the more luminous portions are clouds, is supposed from this, that the belts do not come up in all their strength to the edge of the disc, but fade away gradually before they reach it.

The accompanying woodcuts represent three different views of the belts. The uppermost figure gives one of the observations taken by Cassini, in which a number of belts appear, several of them considerably broken and irregular. The middle figure presents an oblique form uniting two adjacent and parallel belts, as if the one were sending into the other a portion of its substance. The third figure gives the planet with the four satellites, where two of them happen to be on each side of the enormous orb.

It has already been stated that Jupiter is attended by four secondaries or satellites, which revolve round it in the same manner as the moon does round the earth, keeping, like our satellite, one face invariably

presented to their primary. The discovery of these four moons of Jupiter was made by Galileo, in the year 1610, being one of the earliest achievements in the science of astronomy after the invention of the telescope, and being such as to force him to conclusions diametrically opposite to the absurd notions which were upheld by the authority of the church, and also by popular belief, respecting the motion of the sun round the earth. Yet so wedded to their opinions were those bigoted parties, that many of them refused to look through the great discoverer's instruments, alleging and indignantly declaring that the doctrine which was to be taught by the new lights was rank heresy, that the system which was to be revealed depended wholly on optical deception, or that it was an invention of the Evil One! The telescope with which Galileo made his observations magnified about thirty-three times. What then may yet be expected through the aids of such instruments as Lord Rosse's great telescope!

Jupiter with its satellites has been studied with great attention, affording various most important lights in astronomical science. These have resulted partly from the remarkable brilliancy of the four satellites, which are large enough to present measurable discs in telescopes of great power; but still more by means of their eclipses, which, as they fre-

quently happen, are readily observed, affording valuable data, such, for example, as the determining of terrestrial longitudes.

The satellites of Jupiter, which are known, according to their distances from their primary, as the *first*, *second*, *third*, and *fourth*, are of about the same size, or a little larger than our moon. The first, having a diameter of 2508 miles, revolves round the primary in one day, 18 hours, and 28 minutes; the second, having a diameter of 2068 miles, revolves in 3 days, 13 hours, and 14 minutes; the third, having a diameter of 3377 miles, revolves in 7 days, 3 hours, and 43 minutes; and the fourth, with a diameter of 2890 miles, revolves in 16 days, 16 hours, and 32 minutes. These satellites frequently eclipse the sun to Jupiter; and are also eclipsed by their primary, though never all at the same time, so that the planet's dark side is never altogether without moonlight.

The satellites of Jupiter have been of great service, particularly in suggesting the theory and fact that light does not travel instantaneously, but has a gradual progress and definite velocity. It came to be discovered that the eclipses of these bodies uniformly took place sooner than was to be expected when the earth was nearest Jupiter, and later when our globe was at the greatest distance. A Danish

astronomer, in 1675, solved the difficulty by supposing that light required some time to propagate itself, a conjecture which was subsequently confirmed by other observations. It was found that a difference of sixteen minutes and a half existed between the times when the eclipses were seen, when Jupiter was nearest to the earth, and when he was farthest distant; and it was concluded that light requires this space of time to travel across our globe's orbit, which is 190,000,000 miles in diameter, and that consequently light flies with a velocity of about 192,000 miles every second.

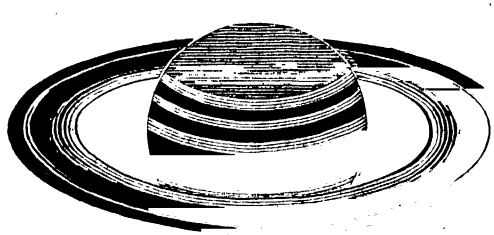
There are many interesting and sublime phenomena which must be presented to the astronomers who inhabit Jupiter, if any such there be, connected with these four satellites, as well as with the enormous primary itself, demonstrating to such observers, perhaps, that "power belongeth unto God"—that "his greatness is unsearchable"—that he "doth great things and unsearchable,"—and "marvellous things without number."

SATURN.

THIS planet is situated at nearly double the distance from the sun of Jupiter, the amazing interval of 410 millions of miles intervening between the orbits of the two, although next to each other in the order of the system, so far as is yet known. Saturn is not greatly inferior to Jupiter in respect of magnitude, being about 79,000 miles in diameter, and therefore exceeding our globe in bulk nearly a thousand times. Its density, however, is remarkably low, being but a little more than an eighth of the earth. It takes nearly thirty years to perform its revolution round the sun. It performs a rotation on its axis in about ten hours and twenty-

nine minutes, and revolves round the sun at such a distance, that that central luminary must be diminished to about one-ninetieth part of the size he presents to us, and the heat and light in the same proportion. It will result from these conditions that the character of Saturn's seasons, and consequently of its living inhabitants, if any such there be, must be greatly different from such as we can imagine. For instance, water cannot exist on its surface ; since, being heavier than the planet itself, every solid would float upon it. Its surface appears slightly marked by belts like those of Jupiter ; so that if, as is probable, these bands are owing to the existence of clouds, there must be a liquid of some kind, which, being converted into vapour, produces such clouds.

Saturn, as seen through a telescope, is the most



Telescopic appearance of Saturn.

remarkable of all the planets, being surrounded by *rings*, and attended by seven satellites. To the naked

eye, however, it presents such a dull and pale leaden hue, that the ancient astrologers accounted this planet as a cheerless member of the celestial bodies, and as the source of malign influences upon the inhabitants of our globe. The rings, however, form a beautiful appendage, of such an unique character, as to constitute one of the most wonderful phenomena connected with the solar system. It was not long after Galileo had applied his newly-invented telescope to the celestial regions, that he caught a glimpse, the first that had ever been obtained by mortal man, of the singular circles which surround the globe of Saturn ; although, in consequence of the inadequate power of his instrument, he was unable to ascertain the nature of the object he was observing. His conclusions, therefore, were inaccurate, sundry circumstances of a most peculiar character in the appearances of the rings serving to strike him with amazement, and to baffle his conjectures. The greater part of half a century elapsed before the real nature and form of the marvellous appendage were discovered. At length, about forty-six years after the invention of the telescope, that ingenious mathematician and distinguished astronomer, Huygens, so far improved the telescope and increased its magnifying power, being to the extent of two or three times greater than before, that at length the true cause of the surprising phenomena of

the rings was ascertained, establishing the fact that Saturn is surrounded with an immense circular body, separated from the planet by a space of many thousand miles, and that the diameter of this appendage, in proportion to the diameter of Saturn, is as 9 to 4.

The rings, two in number, are broad and flat, but extremely thin, being concentric with each other, both lying in one plane, and separated from each other by an interval of something less than two thousand miles only, throughout their whole circumference. The following are the dimensions of these rings as calculated by some of the most eminent astronomers, from measurements made by means of superb inventions where the micrometer is attached to the telescope :—The interior ring is separated from the planet by a space of 19,090 miles, while the exterior diameter of the largest ring is 176,418 miles, although the thickness of either ring does not exceed 100 miles.

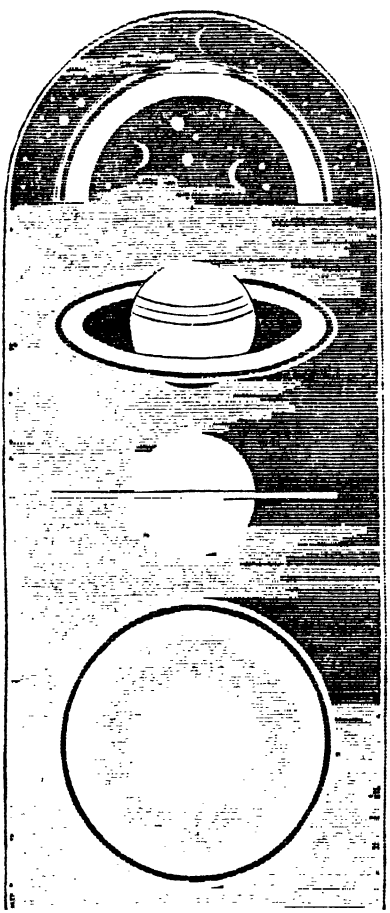
This double ring is clearly a solid opaque substance or body, as appears by its throwing a well-defined shadow upon the planet which it surrounds, on the side nearest the sun, and also from the fact of the other side of the ring receiving a corresponding shadow thrown upon it by the planet. This appendage is carried along with Saturn in the annual

revolution of that orb round the sun; and therefore, were it not a solid body, it would either fly off from the planet, or its centrifugal force, caused by its rapid rotation, would derange all its parts, so as that they would, when thus displaced, be dispersed around the body of the planet. Taking the surfaces of the rings altogether, they contain more than a hundred times the area of our globe, and therefore may afford ample accommodation for a corresponding increase of inhabitants.

"The rings of Saturn," Sir J. Herschel has remarked, "must present a magnificent spectacle from those regions of the planet which lie above their enlightened sides, as vast arches spanning the sky from horizon to horizon, and holding an invariable situation among the stars. On the other hand, in the regions beneath the dark side, a solar eclipse of fifteen years in duration, under their shadow, must afford (to our ideas) an inhospitable asylum to animated beings, ill compensated by the faint light of the satellites. But we shall do wrong to judge of the fitness or unfitness of their condition from what we see around us; when, perhaps, the very combinations which convey to our minds only images of horror, may be, in reality, theatres of the most striking and glorious displays of beneficent contrivance."

Towards the equator of Saturn, these rings will

appear to span the firmament like glorious arches of different degrees of magnitude; until, indeed, as the approach is made to the line which is astronomically supposed to gird the planet in the middle, they will present complete semicircles, something in the way represented in the uppermost of the accompanying figures, where also a view of the nocturnal firmament of Saturn is imagined. The appearance of the rings necessarily cannot be the same at all times to us; but never are the views which our astronomers obtain of them, and the planet which they encircle, other than extremely interesting. When beheld through powerful telescopes to the greatest advantage, they appear as is rudely sketched in the second figure from the top of the woodcut, where they look like ellipses or ovals, with Saturn in the middle.



But it is only once in about fifteen years that the appendage appears so open as here shown; in fact, the rings are sometimes altogether invisible as contemplated from the earth; and again they present, in due turn to us, only a line of light on each side of the planet, as in the third figure. At no time are the rings more fully expanded to us than as shown in the second figure. However, could we view this surprising appendage at right angles to our line of vision, it would appear as represented in the fourth, or lowest figure of the woodcut, and not in the form of the oval, for it can only be seen by us obliquely even when we are in the most favourable position which our globe can furnish for contemplating the singular phenomenon.

When viewed with a telescope of very superior power Saturn's encircling appendage is seen to exhibit several black lines. Indeed, one of these, near the outer margin, is conspicuous, and seems to divide the ring into two, the separation of which was first noticed by Dr. Herschel. Other astronomers have observed several divisions, extremely close, and one stronger than the rest, dividing the outer ring about equally. In consequence, however, of our great distance from Saturn, and of the want of more extensive as well as clearly ascertained facts, either to strengthen or to weaken the observations last

noticed, it will be best to withhold all positive opinion.

Saturn is accompanied by a more numerous train of satellites than any of the other planets, so far as has yet been ascertained. No fewer than seven have been discovered accompanying this enormous body, to diffuse the light of moons over its surface, in the absence of the powerful rays of the sun. The most distant of these attendants is nearly as large as Mars. Excepting this last and extremely remote one, the orbits of these satellites are so near to being in the same plane with the equator of Saturn itself, and consequently with the ring, that they appear merely to move from side to side of his disc. The two inner moons, which skirt the outer edge of the ring, can only be seen by the aid of the most powerful telescopes which had ever been constructed prior to that of Lord Ross, and even then only under peculiar circumstances, when they may be perceived like two minute beads strung upon the very thin thread of light, formed by the edge of the ring. The three next satellites are also very small comparatively; the last but one, which was the first discovered, is tolerably conspicuous. The revolutions of these attendants vary from about twenty-two hours and a half, or nearly a day, to about seventy-nine days, that is, beginning with the first and proceeding onward to

the largest as well as the most distant. However, astronomers have not studied the satellites of Saturn with an attention equal to that which has been bestowed on the moons of Jupiter. It has, nevertheless, been ascertained of some of them that, according to the usual law of secondary planets, their rotations on their axis and their revolutions round their primary are performed in the same time; and, therefore, like our moon, they must always present the same face to Saturn, the centre of their system.

These moons, like those of Jupiter, are subject to eclipses, although, owing to their great distance from the earth, such phenomena are seldom observed. It must be, however, that such a numerous train of secondaries journeying round their primary at very different distances, and also in equally different periods, will produce wonderful scenes in the heavens, as well as upon the surface of the mighty planet, Saturn. How striking will be the effect when all the seven satellites appear at one and the same time above the horizon, in all the different phases from the new to the full moon; some passing others at great rapidity, and each causing the shadows of the objects on the surface of the primary to be projected in their proper direction, in obedience to its relative position in the heavens! And then all these diver-

sified phenomena are to be considered along with those of the magnificent encircling rings of their enormous central body. Surely, "Great and marvellous are thy works, Lord God Almighty!" "Who can utter the mighty acts of the Lord!"

URANUS.

O a very notable era in the history of Astronomy attention must now be directed. Even after great advances had been realised in this science in consequence of vast improvements in the construction of instruments for observation, Saturn continued to be regarded as the most distant planet from the sun, and as constituting the outermost confines of the planetary system. Still there are grounds for believing that it was frequently noticed by astronomers from the period when the telescope was invented, but that it was mistaken for a fixed star. It was not till near the end of the eighteenth century that its discovery by

Dr. Herschel took place, forming a new era in the history of astronomy. This eminent philosopher recognised Uranus in 1781, from its variable position, to be a planet. It at first obtained the name of Georgium Sidus, in honour of the king, the continental astronomers giving it the appellation of Herschel. It is now, however, generally called Uranus, in obedience to the order in which the more remote of the principal planetary bodies have been designated; for, according to the heathen mythology, Jupiter was the father of Mars, and Saturn the father of Jupiter; therefore, a still more distant planet ought to receive the title of the father of Saturn.

Uranus is so immensely removed from us as to render it impossible to form any distinct or definite conclusion with regard to its physical state; appearing nothing but a small, round, uniformly illuminated disc, destitute of rings, belts, or spots. Its distance from the sun is about 1840 millions of miles, being more than twice that of Saturn, and, therefore, doubling the diameter of the system; so that the area of the space comprehended by this planet is four times the dimensions formerly supposed. And yet throughout every portion of the marvellous expanse the influence of the central luminary is felt, although Uranus receives no more than about three hundred

and sixty-two times less light and heat which we enjoy. Its diameter is about 35,000 miles, the planet being more than 80 times the size of our globe. It revolves round the sun in about 84 years, in an orbit 11,000 millions of miles in circumference; and, therefore, has not performed more than about three-fourths of a revolution since its planetary nature was ascertained. With regard to its rotation on an axis, nothing positive has been established, although there remains little doubt, judging according to the analogy of all the other planets, that it does so rotate. Uranus was discovered, by the illustrious astronomer who detected the planet, to be attended by six satellites, although of these only two have been satisfactorily proved to exist. The two which have been more particularly observed circulate round their primary in orbits almost perpendicular to the ecliptic, while the planet itself is but very little inclined to it; and, what is very remarkable, the said two satellites are further supposed to have a retrograde motion—that is, being in a contrary direction to that of all the other planetary motions—from east to west, instead of from west to east.

And does Uranus move on the utmost boundary of the solar system? Did astronomy, by the discovery of the elder Herschel, at length reach to that farthest boundary? Not so, for the presumption has

recently been discovered to be rash and erroneous; the mode in which such a discovery has been made, constituting, it may be said, another era in astronomical science.

Uranus was known to have anomalous motions, a circumstance which set astronomers to conjecture causes for such a fact, several being assigned. One mode of solving the difficulty was the suggestion that there still existed a planet, although altogether unknown, which gave rise to the irregularities of Uranus. This idea was entertained, for instance, by Sir John Herschel in England, and in France by M. Leverrier. It is to the efforts and reasonings of the latter philosopher that science is indebted mainly for the grand recent discovery, being one of the noblest achievements of modern times; for, after the many necessarily most intricate calculations, he pointed out in June, 1846, that part of the heavens where the new planet might be expected to be found; and, on the 23d of September, of the same year, it was actually detected at the first search for it by M. Galle of Berlin. Since that time it has been observed by several astronomers, — the names of Janus and Neptune having been suggested for it, although neither seems to have been as yet determined upon. It ranks as third planet of our system in point of magnitude, having a diameter of 50,000

miles, and a bulk 250 times that of the earth. Its distance exceeds 3000 millions of miles. It is believed to be attended by at least one satellite, and also to be surrounded by a ring like that of Saturn.

Having presented a few brief notices of some of the more general and obvious phenomena of the solar system, so far as astronomical observation has yet reached, let us guard against the positive conclusion that all the planets belonging to this system have now been discovered and described. If we reason according to probabilities, or the history of the past, our presumptions would take quite an opposite direction, and we should be inclined to predict that some future Herschel, Leverrier, and Galle are to astound the world, by announcing that one or more planets, which have hitherto eluded not merely the naked eye but the detection of the telescope, have all along been performing the most regular revolutions around our sun, and this, too, perhaps, in orbits much nearer to us than Uranus. It is demonstrable in the most perfect and satisfactory way, that unless the inhabitants of Jupiter and Saturn, supposing such to exist, have a natural power of vision much stronger than ours, they must be wholly ignorant that such a globe as the earth exists at all. Even if a planetary sphere of twice the dimensions of our earth were revolving between the orbits of Jupiter and Saturn, it would

for ever elude our naked eyes, and even the discovery of our telescopes for ages, unless a most minute and persevering survey of the heavens were pursued by a body of astronomers.

Here a grand train of speculation is forced on one's attention :—we ask, how wonderfully different must be the constitution of the inhabitants of Uranus, for example, from that of those who reside on the earth! And yet how narrow and limited would be our conceptions of the power, wisdom, and goodness of the Creator, did we pronounce it impossible that rational beings should move, and breathe, and adore God in that to us immensely remote world; or that we should deem it unphilosophical to suppose that the days and nights of 42 years length to them are but as the days and nights of 24 hours to us. Perhaps the discovery, perfect knowledge, and intense admiration of these and many similar subjects, may constitute some of the exercises of the beatified in that future state, when the intellect of man will be continually advancing to greater and greater light, and to a purer and more elevated height whence to survey the works and attributes of the Deity. What order and harmony may, then, be clearly perceived to pervade the universe, and throughout the infinitudes of space! what unity and mutual relationship! plainly indicating that notwithstanding all their

varieties and individual characteristics, they have been formed and are constantly sustained by One Supreme Spirit and Intelligence.

How different are the distances of the planets from the central luminary whose influences they, each and all, receive and obey! how varied their magnitudes, conditions, and accompaniments! Yet they are, every one of them, subject to certain uniform and general laws, which prove that the same attributes have impressed their evidences and tokens throughout the entire system. With regard to the relative magnitudes and distances of these wandering stars, in respect of the sun, some idea may be conveyed by means of an illustration which has been proposed by Sir John Herschel. Suppose any well-levelled large field: on it, in the centre, place a globe two feet in diameter, to represent the sun; a grain of mustard-seed, placed on the circumference of a circle 164 feet in diameter for Mercury, this circumference being for the orbit of the planet; a pea, on a circle 284 feet in diameter, will represent Venus; another pea for the earth, on a circle 430 feet; Mars, a rather large pin's head, on a circle of 654 feet; Juno, Ceres, Vesta, Pallas, and Astræa, minute grains of sand, in orbits of from 1000 to 1200 feet; Jupiter, a moderate-sized orange, in a circle nearly half a mile across; Saturn, a small orange, on a circle four-

fifths of a mile; and a full-sized cherry, or small plum, for Uranus, upon the circumference of a circle more than a mile and a half in diameter. It will also serve to awaken a solemn awe and profound reverence within us, if it be considered that the united masses of all the planets are calculated not to exceed a six-hundredth part of the mass of the sun; and yet that, after all, the whole of the vast solar system forms, comparatively speaking, but a point in the infinitude of the universe; so that our entire system, sun, planets, and all, can be no larger in the view of the inhabitants of the nearest fixed star, if such there be, with capacities like those of man, than the smallest of the satellites of Saturn display themselves to us.

COMETS.

EXT as to comets: * These constitute a class of bodies belonging to the solar system, which are distinguished from the planets by their physical appearances and the great eccentricity of their orbits. They are, in fact, the most extraordinary objects yet observed within the domain of astronomy, having baffled the keenest researches of science by the very eccentricity mentioned, being governed by laws or influences which have not to

* The name which these most remarkable bodies have received is derived from the Latin word *coma*, signifying *hair*, because of the bearded appearance they frequently exhibit.

this day been ascertained and understood. By reason of the smallness of their diameters, and a nebulosity which renders them ill adapted to reflect the rays of light, the greater part of them are only visible in the telescope, continuing to be so only during a short period of time, for, as they advance to, or recede from, the sun, almost in straight lines, and with prodigious velocities, they are soon carried far away and beyond the limits of vision. Strictly speaking, no more than three are known to belong to our system, as being dependent on our great and central luminary. From these few observations it will not appear at all wonderful, that none of the celestial bodies have given rise to more speculation and conjecture than comets. Their strange appearance has in all ages been a terror to the vulgar, who have looked upon them as bad omens—as the forerunners of war, pestilence, famine, or some direful events. From a passage in Miss Aikin's "Memoirs of James the First," it appears that even at a comparatively modern date, not only mighty monarchs, but private individuals, considered the sign as sent to themselves, setting a double guard on all their actions. Thus, Sir Symonds D'Ewes, the learned antiquary, having been in danger of an untimely end, by entangling himself among some bell-ropes, during the appearance of a comet, makes a memo-

randum in his private diary, never more to exercise himself in bell-ringing when there is a comet in the sky.

Some part of the modern doctrine, however, concerning comets, was current in several of the schools of the ancients. The Pythagoreans and certain others regarded them as being in some degree analogous to planets, performing their courses in fixed or regular periods. But there was a sufficiently numerous class of absurd fancies connected with the strange visitants to overbalance such a reasonable conjecture. Aristotle conceived them to be of the nature of meteoric bodies,—an opinion which generally prevailed from the commencement of the Christian era to the time of Tycho Brahe. Some believed them to be huge animals that swam round the sun like fishes; and Bodin imagined that they are spirits which, having long dwelt on the earth, are about to be translated to heaven. At length, from the observations of Tycho Brahe, Kepler, Newton, and others, it was found that comets are bodies which move round the sun as do the planets, but in orbits most remarkably elliptical or oval,—opaque bodies illumined also by our own luminary; their orbits being, as already said, very eccentric ellipses, although there be vast differences amongst them in this respect. In fact, they appear in all parts of the heavens, move

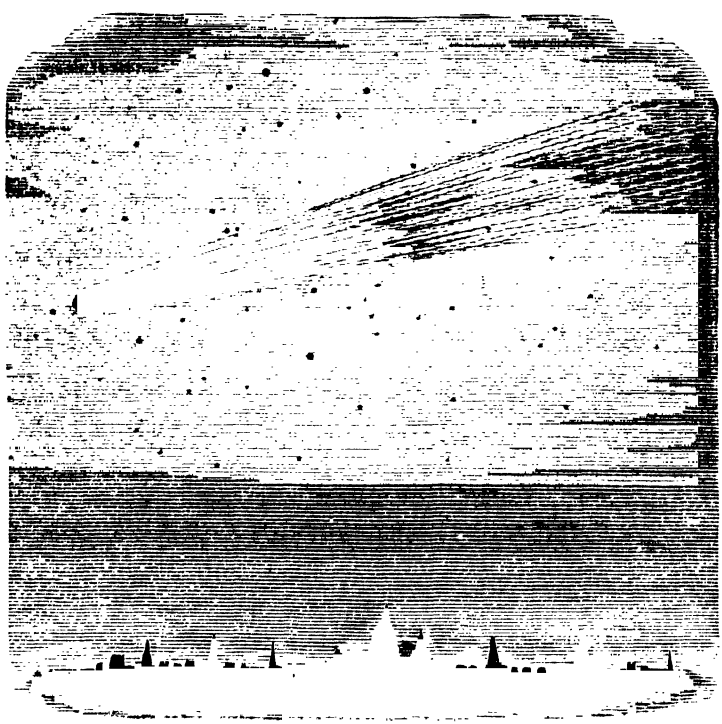
in all directions, and travel with greatly different degrees of velocity.

Comets are generally characterised as consisting of a *head* or nucleus, and a *tail*, the head usually being an ill-defined nebulous spot, brightest towards the centre, the tail a luminous, lighter substance, resembling a vapour, streaming far out from it in a direction contrary to its forward motion. There is sometimes not only no visible tail, but at times there appears a vacancy between the body and the enveloping matter of the tail. Generally, however, the tail very much resembles the luminous trains left by bright meteors, or the fiery track of a sky rocket, but without sparks or observable motion. When the tail has attained its greatest length, which occurs when the comet has reached nearest to the sun, it soon begins to decrease, and disappears from the sight about the same time that the nucleus vanishes. There has been no small discussion with regard to the matter of which the tail consists, and even of the nucleus itself. This much has been, at any rate, rendered certain concerning these startling visitants,—they are so far nebulosities, that even their nuclei dissolve into some sort of vapour under the penetrating scrutiny of the telescope. Through the very heart of one of them Sir John Herschel descried a cluster of stars of the sixteenth magnitude. It has

been remarked by the eminent philosopher, Professor Nicholl, that these nebulosities are not immediately connected with the structure of our solar system, but have a much nearer relation to some system in the spaces external to our limited sphere. There seems to be no essential or near tie between them and us. The Professor therefore conjectures that these hazy bodies, now and then reaching our system, and quitting it without ever producing an appreciable effect, have therefore a *home* in the universe, and that they hold relations with some grand scheme of matter in a state of similar modification; and also, that since they approach us from all quarters of the heavens, the nebulosities in which they have their root must lie around us on every side, and be profusely scattered among the intervals of the stars.

No satisfactory explanation has ever yet been proposed to account for the nature of the luminous tail of a comet. An opinion has often obtained attention, viz., that this train consists of matter which has been left or thrown behind, as it were, by the comet during its fleet course, and which continues for some time in the same position, like the smoke from a steamer on a calm day. This conjecture, however, is quite inconsistent with certain facts connected with these visitants; such as that the tail, after the comet has reached the point nearest to the sun, rather pro-

jects before it than is left behind. Sir Isaac Newton thought that the tail was formed by a thin vapour raised by the heat of the sun from the comet. The great probability is, that the condition of the tail is in some way connected with the effect of the sun's heat upon the matter of the comet, because the size of the tail increases as it approaches the sun, and also because it is much greater when the comet begins to quit this nearest point than on the approach to it.



The train of luminous matter, mist, or vapour,

attendant upon a comet, is sometimes of enormous length, extending to eighty and a hundred millions of miles. The comet of 1680, which was observed by Newton, with a head no larger than a star of the second magnitude, had a train calculated to be 123,000,000 miles in length; so that if the comet had been in the sun, its tail would have extended far beyond the earth's orbit. The length of the tail of the celebrated comet of 1811, was calculated to be about 168,000,000 miles. There was a comet in 1744, which had six tails, spread out in the manner of a fan across a mighty space. It is to be borne in mind, however, that there are comets, especially such as are invisible to the unassisted eye, which have no luminous tails; and yet, in the case of some of these, the comet is very bright, when beheld through a powerful telescope.

As has already been mentioned, comets in bygone and more superstitious times than the present, were regarded as being the harbingers of direful events to the inhabitants of the earth, or to be fraught with the most fearful woes, destined to "shake from their horrid hair," famine, pestilence, and wars upon the nations. Such terrors have become far less predominant than formerly; and although almost every year such visitants are making their appearance in the heavens to the astronomical observer, no appre-

ciable effect is thence occurring in the moral or physical condition of our globe. Philosophers will tell us, that, in so far as we know of the constitution of comets, we might as well attempt to ascertain to what extent a cloud which is driven against a mountain would tend to break off the top, as to speculate upon any mechanical danger to the earth from contact with such whiffs of vapour. And yet, from being involved in the enormous tail of the comet which visited us near the beginning of 1843, we are said to have escaped merely by being fourteen days behind it. Now, it is not for us to state what would have been the result, had that mist, thin though it assuredly was in substance, brushed our earth, with its almost inconceivable swiftness. Is it not probable that such a sudden and sweeping visitation might have produced a most inconvenient change in our atmosphere, the breathing medium of organic beings ?

This enormous comet first appeared in the constellation of Orion, and was visible immediately after sunset. In England it was not unlike an auroral streak of amazing length, but its head was never within the scope of our gaze, although visible in latitudes farther to the south, where it looked like a small star with an immense vaporous envelope, behind which its measureless tail streamed. So wonderfully

large was the nucleus of this comet, as to have a breadth or diameter of not less than one hundred thousand miles; while its tail, in some portions of it, was thirty times as broad, that appendage extending in regard to length to one hundred and seventy millions of miles. A variety of peculiarities were observed relative to this enormous visitant, among which may be mentioned that its velocity was so prodigious that one part of its mass equalled one-third of the speed with which light travels.

Frequently, since 1843, have comets made their appearance within the limits of the solar system. In August, 1844, not far from the star Arcturus, in the constellation of Bootes, a comet was descried; another was seen in the September of the same year, near to Cetus; another appeared in January, 1845, being visible in the West Indies; and in the following month another was detected by observers in England. In short, within the space of fourteen months, about the period just now particularly mentioned, not less than half-a-dozen of comets were observed, either in one part or another of our globe.

KNOWN COMETS.

THE number of comets which have been observed in the course of ages amounts at least to seven or eight hundred, although not above 150 have been subjected to scientific examination and inquiry, so as that they might be identified should they again make their appearance. Most probably very many of these bodies escape the observation of the astronomers and their telescopes. It is calculated by Herschel, Arago, and others, that the number of comets which occasionally visit the solar system within the orbit of Uranus, may be several millions,—not less than *five*. Strictly speaking, however, no more than *three* comets are *known* to return with regularity, and whose periods of revolution have been calculated.

That which is named after Halley, from the astronomer who first calculated its period, has excited the most attention. It appeared in 1682, when Halley confidently maintained that it was identical with the comet of 1607, and of 1531 ; and with equal assurance he foretold its re-appearance in about seventy-five and a half years. The events have substantially confirmed the predictions, viz., in the years 1759 and 1835. The period of this comet then, as well as of two others immediately to be noticed, is considered as being determined, and also that there are comets permanently connected with our system. Still, it may here be observed, that the revolution even of such known visitants round the sun in fixed periods, and this so long as the stability of our system continues, may be said to be problematical, seeing that their orbits are wholly dissimilar from any other. As they cross the planetary paths, who can tell that any one of them may not experience the fate of Lexell's, which, by the action of Jupiter, was first twisted, so to speak, from its diverging orbit into a comparatively short ellipse; and then, after making two consecutive revolutions round the sun, was by Jupiter again twisted back, and driven off into the far abysses of infinite space, perhaps never again to visit our heavens.

Halley's comet was for a long period the only

body of the kind whose regular periodical appearance was ascertained. In 1818, however, a small comet, which cannot be easily seen without a telescope, was

discovered, which is called Encke's, from Professor Encke, who first made known its period. This comet performs its revolution in a shorter space of time than any that has yet been observed. Its orbit is elliptical, and it only requires three years and three months to perform its whole revolution, having regularly visited our system, since the time of its

having been first noticed. There is this remarkable fact belonging to its successive returns, that at each period it is found to be a little earlier in its approach to the sun than on the previous visit, as if its orbit was lessening by degrees; as if, indeed, the comet might at some time fall into our central luminary altogether. Its orbit penetrates within that of Mercury, but does not extend so far as the orbit of Jupiter.

The third comet known to have a regular period, is named Biela's, from M. Biela, who, at the time it was first observed, viz., in 1825, was an officer residing at Prague. It revolves round the sun in a period of $6\frac{3}{4}$ years. It was seen in 1826, 1832, and 1839; also in February and March, 1846. Biela's is a very small comet; it has no tail, and cannot be seen without a telescope. In 1832, it passed through the earth's path, only about a month before the arrival of our planet at the same point; so that comparatively inconsiderable as this body may be, had it been brought into immediate contact or collision with our globe, the existence of organic beings might, perhaps, have been fatally affected.

There is a fourth comet, which was discovered by Father de Vico at Rome, in August, 1844, which is supposed to be remarkable for the shortness of its revolution round the sun. Its elliptic orbit, as well

as the perturbations to which it may be subject, have not yet been calculated with sufficient closeness to warrant a confident prediction of the time of its return.

A number of most interesting questions suggest themselves with regard to comets. What is the nature of their constitution? Whence come they? Whither do they go? What purposes are they intended to serve? Were they ever other than they now are? Are they to remain as they appear, nebulosities? Are they planets, stars, in the course of formation? Are they messengers in the meantime speeding from one system to another, winding through tortuous courses of incalculable extent in the abysses of illimitable space, linking the whole infinity of worlds in one sustained chain of harmonious existence? or are they fraught with lessons to rational and responsible beings, which we, in the present state, are not able to read and interpret?

Professor Nicholl has eloquently said, that "unconnected though these bodies are in most particulars with the planetary scheme, it is plain that between them and that system, and particularly between them and the sun, there exist very powerful sympathies; for, although they escape again, they are yet drawn, through the force of these sympathies, from the profoundest depths, and constrained, for once at least,

into definite motion." The same admirable thinker argues with great force to the effect, that over the comets, whiffs of vapour though they be, the law of gravitation prevails, come from where they may. Such views and reflections have drawn from a powerful pen the following exalted sentiments :—"Shall the material thing, inorganic, inert, impercipient, move on in this wondrous perpetuity; and shall the soul that discerns its order, and tracks its course, and detects its laws, and speculates on its constitution, be swept away as nothing before it? Shall unconscious matter last, while the mind, to which alone its functions are subservient, which interprets its mysteries, and reads in them the signature of God, vanish like the passing wind? Shall the knowledge and thoughts of men be handed down in endless genealogy, teaching and inspiring the soul of other times; and shall the conscious creature that called them into being be blotted ignominiously from creation? Impossible! it cannot be but that they, through the medium of whose thought we now gaze at the skies, witness elsewhere the excellence of their past toils, the triumph of their studious meditations."

The strange and anomalous bodies of which we have been speaking are all the creation of Him who is "wonderful in counsel and excellent in working," and they must be intended to accomplish important

ends, worthy of One who hath "established the world by his wisdom, and hath stretched out the heaven by his understanding." Exalted minds see no improbability in thinking that these filmy vaporous bodies may be intended for the habitation of various orders of intellectual and sentient creatures, to whom the Almighty displays himself in a peculiar manner, and with manifestations of his ineffable attributes.

"Lo! from the dread immensity of space,
Returning with accelerated course,
The rushing comet on the sun descends;
As he sinks below the shading earth,
The guilty nations tremble.
. . . . . Th' enlighten'd few,
Whose godlike minds philosophy exalts,
The glorious stranger hail; they feel a joy
Divinely great—they in their powers exult;
That wondrous force of thought, which mounting spurns
The dusky spot, and measures all the sky;
While, from his far excursion through the wilds
Of barren ether, faithful to his time,
They see the blazing wonder rise anew
To work the will of All-sustaining Love."

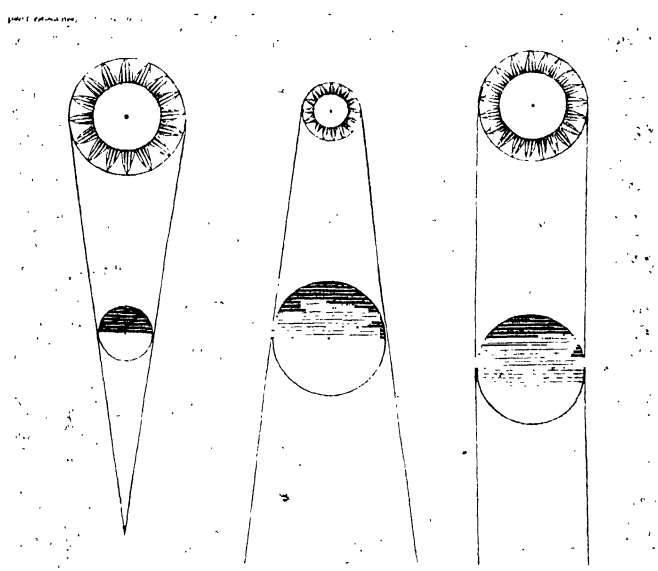
ECLIPSES.

IN the Greek, the word from which our term *eclipse* comes conveys the idea of fainting away, or dying; and in former times, ignorant superstition having dominion, when an affair of this kind took place, it was an object of terror, and of sometimes absurd efforts to avert the dreaded evils supposed to be connected with the occurrence. We read that the ancients imagining that the moon was in pain and sore trial at such times, called her eclipses the labours of the moon, and had, on some occasions, recourse to paltry means to break the enchantment which was thought to have her in its power, such as making frightful noises to drive away the spell. An eclipse of the sun was regarded as an expression of that grand luminary's

displeasure, on account of atrocious crimes which had either been committed, or which it was in contemplation to perpetrate. Under such an impression, the Medes and Persians, centuries before the commencement of the Christian era, when about to engage in ferocious contention with another nation, threw away their weapons of war, and entered upon terms of peace with the enemy, because an eclipse was observed at the time.

Eclipses are caused by the position of the earth and moon in relation to each other and to the sun. An eclipse of the moon is produced by the earth coming between the sun and moon; for our globe being an opaque body enlightened by the sun, it must throw a shadow towards and upon the moon when she happens to pass through these spaces which the shadow reaches and where it falls. The sun and the earth being both spherical bodies, were they of the same or equal magnitude, the shadows of the earth would be necessarily cylindrical, as shown in the figure to the right of the following woodcut. Or, again, were the sun smaller than the earth, the shadow of the latter, so long as it derived its light from the former, would grow wider and wider the farther that shadow extended from the earth, as in the central figure of the woodcut. So truly and much would this be the case, that even the largest of

the superior planets would be eclipsed by our globe, whenever it came between them and the sun. But the sun is vastly larger than the earth, and, therefore, the shadow of the earth is a cone which must somewhere end in a point (see the figure to the left), a point, however, so much more distant than the moon is from the earth, as that very decided eclipses of the satellite are produced.

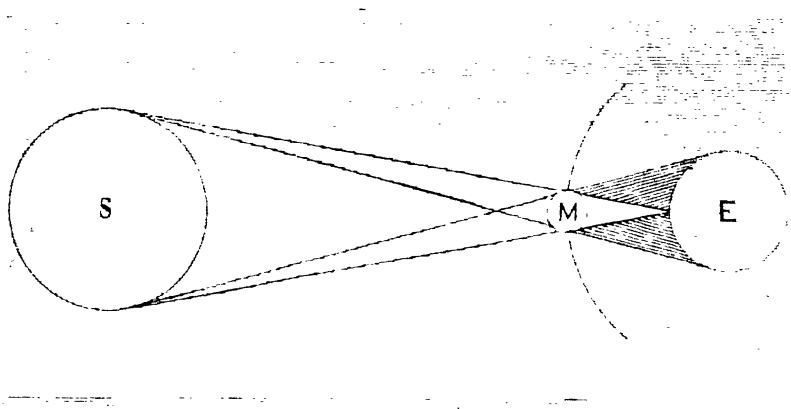


Did the places of the moon's orbit coincide exactly with those of the earth's, instead of crossing or intersecting each other, the lunar orb would be totally eclipsed at the period of every full moon, by passing through the centre of the earth's shadow. With

regard to an eclipse of the sun, this is caused by the moon coming between the sun and the earth, the lunar orb throwing her shadow over a certain portion of our globe,—any spot, indeed, upon which her opaque body intercepts the light of the grand central luminary from falling. Every one knows how completely a very small body or object may hide a very large one, if the former be brought sufficiently near to the eye; and therefore the moon, though small indeed when compared with the sun, is capable of obstructing his effulgence from reaching that point or spot of the earth where the lunar shadow falls, however limited that spot may be; while on either side of this spot a small portion only of the sun's disc will be observable, but increasing gradually as you recede from the said point or spot which happens to be totally eclipsed. A diagram will plainly illustrate this.

Let the circle S stand for the sun, M for the moon, and E for the earth. Draw straight lines from the extreme edges of the sun's disc, to the edges of the moon on the same side; these lines will meet in a point touching the sun's surface, forming the boundaries of the moon's total shadow, so as wholly to shut out the sun's light from the included angular space. Next draw straight lines from the same points of the sun's disc as before, but let these last

lines traverse to the opposite sides of the moon, then it will be found, when they reach the earth, that these last drawn lines include a large portion of the earth's surface, where a much fainter shadow is thrown than at the totally obscured point. Let it be observed, that the fainter shadow must gradually decrease as you recede from the wholly darkened spot, until it ceases altogether.



It has been already said that the places of the earth's orbit and those of the moon's do not coincide, but cross and intersect each other at parts called the nodes. In other words, the moon's orbit is not on the same plane with that of the earth, but is inclined at an angle of something more than five degrees; consequently, when the moon is at any considerable distance from the nodes, her position at the time of

conjunction is not exactly in a line joining the earth and moon, but either above or below it—either passing on one side or another,—and therefore a total eclipse of the moon is not produced by any interception of the sun's beams. Partial eclipses are caused when the moon, in passing the earth, is not directly in a line with the sun, but a little on either side, so as that the edge of one side of the moon only dips into the disc of the sun.

The sun can never be eclipsed but to one particular part of the earth,—that side of the earth at which he is seen; whereas an eclipse of the moon is visible to all who are on that hemisphere where the lunar orb is seen. Her disc, however, is seldom completely obscured, because some of the solar light generally reaches it, through the refracting influence of our own atmosphere. When the moon is eclipsed she experiences a real diminution of her borrowed light; but when the sun is said to be eclipsed, he experiences no such diminution, there being only an eclipse of the earth, by the shadow of the moon falling upon a certain portion of our globe.

The moon arrives nearly at the same position in relation to the earth, after an interval of about eighteen years and ten days. Accordingly, after a period of the extent mentioned, the series of eclipses recommences nearly as before. A great solar eclipse, visible

in England, will occur on the 15th of March, 1858; but a still more remarkable eclipse of the sun will take place on the 19th of August, 1887.

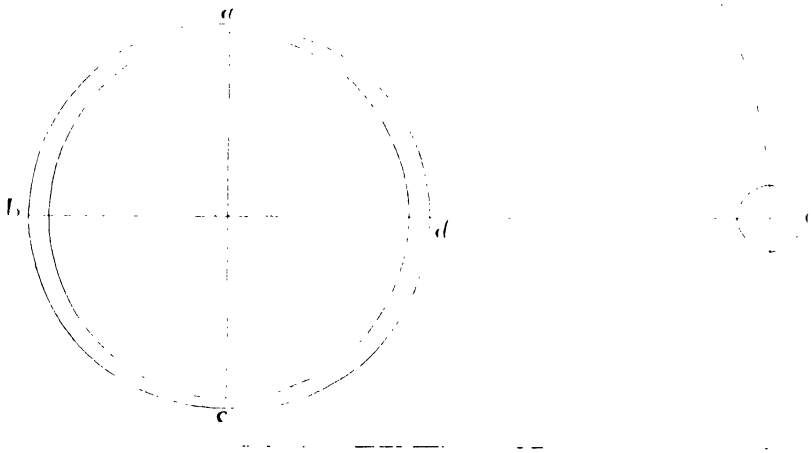
Eclipses are divided into total, partial, annular, and central. A total eclipse is, of course, when the whole face of the luminary is darkened to the observer; while one which is partial refers to a part only of the disc being darkened. An annular eclipse is when the whole is darkened except a ring round the obscure part, like an illuminated border: a thing which can only happen in the case of an eclipse of the sun. In a central eclipse, the centres of the two luminaries and that of the earth are in one and the same straight line, as when in an eclipse the moon passes through the centre of the earth's shadow.

TIDES.

ACCORDING to the laws of mutual attraction, the sun and moon can draw up the fluid, water, towards themselves, producing constant changes in the level of the ocean, the surface of which rises and falls twice, generally speaking, within $24\frac{3}{4}$ hours. Distance reduces the sun's influence to a third of the moon's; and therefore it is the moon's attraction that has chiefly to be attended to. The woodcut will serve to illustrate the subject.

Let *a b c d* stand for the earth, and *e* for the moon: the attraction of the water at *d* must be greater than at *a* and *c*; therefore there will be a high tide at *d* when that point is nearest the moon. Now the earth revolves in twenty-four hours, so that every part of our globe would be influenced by the attraction of the moon once in that space of time, did she not

change her position, thereby adding about three quarters of an hour to the period. There is therefore *one*



high tide at the intervals mentioned on every part of the earth's surface. But why *two* tides in the course of that period? Why should there be a high tide at *b*, corresponding to that on the opposite side at *d*, producing a low tide both at *a* and *c*? The attractive influence of the lunar orb accomplishes the whole; for, while drawing the entire solid earth to itself, as it were, the more distant waters, in respect of the moon, are in a measure left behind, to rise in a heap, at *b* as at *d*, there being necessarily a corresponding drawing off of the waters from the points *a* and *c*. In this manner every portion of the earth's surface is affected twice in little more than twenty-four hours.

When the attractive influence of the sun combines with that of the moon, then we have spring tides; which happens at new and full moon, when the sun, moon, and earth have their centres nearly in the same line. Neap tides occur when the moon is in her quarters, and her influence partly neutralised by the sun's attractive influence operating on the other portions of the earth's and ocean's surface.

THE ATMOSPHERE.

IN meaning the term atmosphere differs from that of the word air in this, that while the latter is the name of the *substance*, the former signifies the *accumulation* of that substance. When thinking distinctly of the air, we have regard to the atmospheric fluid, its properties, and specific effects upon individual objects and substances; but when thinking distinctly of the atmosphere, our ideas have regard to the position and distribution of air around the earth. Still the two terms are often used synonymously in common language.

Atmosphere is compounded of two Greek words signifying *sphere of vapour*, being the whole body of air or other mixture of gases which envelopes a planet,

our attention being now directed exclusively to that which surrounds the earth. But even the subject thus limited, if treated in all its extent, would lead us very far indeed beyond our limits; for we should have to take a view of the mechanical properties of the air according to the science of pneumatics,—of its chemical properties,—of its relative actions, in the department of physical geography,—of its relations to heat, moisture, and motion, as connected with the weather,—of its uses in the economy of plants and animals, &c., &c. Our observations must therefore be confined to a few facts and phenomena belonging to the subject of the atmospheric fluid, or air, either in the condition of the mass, or of the specific material constituting that mass.

The atmosphere everywhere surrounds the earth, by means of which, and the operation of the solar heat, a portion of the waters of our globe is carried up to the region of the clouds in the form of vapour, which diffuses itself over every region of the earth, and is again condensed into rains and dews to supply the sources of the rivers, and to distribute fertility throughout every land. The air, though viewless, silent, scentless, and tasteless, is ever ready to be the vehicle of every subject of sensation with which it may become loaded; and therefore, although appearing to be perfectly simple in its nature, is one of the

most wonderful works and provisions of creation, being susceptible of every imaginable impression, and again giving up those impressions as freely to our sensations, as it receives them from objects and substances of all kinds. The atmospheric volume of the air is the region of the winds, whether fanning the earth with gentle breezes, or heaving the ocean into mountainous billows, and overturning forests by hurricanes and tornadoes. It is the theatre where thunders roll and lightnings flash, and where the fiery meteor sweeps along with its luminous train. It is constituted so as to sustain the principle of life, and to preserve in existence and in comfort not only man, but all the tribes of animated being which traverse the earth, air, or sea, for without its benign influence our globe would soon be tenantless.

The air, or atmospheric fluid, is much more free, and much more susceptible in respect of the action of any and all agents than any other of the constituent elements with which man is acquainted. If powerfully affected by the heat of the sun, or any other heating agent, it ascends or moves away, eluding the full effect of the heating cause; and when cooled beyond the average degree, at any part of the earth, the whole of its mass sympathises, rushing to the assistance of the position, which is consequently cooled, and thus the state and the position which the air

holds upon the earth admirably contribute to the resistance of the extremes both of heat and cold. The atmosphere, in its average state as a body of air, revolves with the earth. Forty or fifty miles is supposed to be the limit of the height, from the earth's surface, which it reaches; and its average pressure is found to be the same, or nearly the same, at any one place from year to year, notwithstanding the various temporary alterations arising from metcorological causes. Everywhere investing our globe to a height far greater than the summit of the most lofty mountains, it yet becomes rarer, or contains less matter in an equal bulk, as you ascend above the mean level of the surface of the earth. Therefore the air must become colder, and also more uniform in its temperature than it is lower down.

The atmospheric fluid is principally composed of two gases—oxygen gas and nitrogen gas; about one-fifth of the whole volume of the air being composed of the first of these, and about four-fifths of the other. This is as to the bulk; but the truer method of taking them, is to reckon according to the weight of the matter in each, and according to the quantity thus taken, we have the proportion of oxygen a little greater than what has just now been mentioned; so that, in round numbers, it is said that, of nine parts of the atmospheric air taken in weight, two consist

of oxygen and seven of nitrogen. So far as has yet been ascertained, there is no variation in the proportion of these two ingredients, under any circumstances, whether of the density of the air, its temperature, the mixture of other matters with it, or anything else; so that we have here another striking proof of the wonderfully-accommodating power or susceptibility and tendency of this most important fluid. It is well known that vast quantities of the oxygen is constantly abstracted from the atmosphere, entering either into combination with solid substances on the earth, or forming gaseous compounds with other substances, while these compounds do not diffuse themselves to any very considerable extent through the volume of the atmosphere; and yet, unless where the communication with the great mass of the air is confined and obstructed, the relative and necessary proportion of oxygen is never diminished, no matter how large and increasing be the inroad made upon it by terrestrial action. How many tens of thousands of breathing animals are continually depriving the atmospheric air of its oxygen within London and its suburbs! How many fires, forges, furnaces, and lamps are making similar drains within the same space! And yet the needful fluid or store is never exhausted, never sensibly diminished; for if it were thus diminished,

and if all the abstracting processes were to continue without the constant usual supply, being obliged to have recourse for a substitute no better than the atmosphere which they themselves produced, the breath of life would soon be at an end,—disease and death the early consequences. So amazing is the abundance and the yielding nature of the needed fluid, so beautifully adapted to all the demands made upon it, so speedy the restoration of any equilibrium that might have been destroyed, that neither loss of nutriment nor lapse of time is ever felt by one of the many millions of the breathing and devouring objects who feed upon it.

The atmosphere is a colourless and invisible elastic fluid; and yet we talk of the blue expanse of air, atmosphere, or sky. Colour exists in the solar rays, without which, or some similar radiance, every object is either invisible, or wears a uniform aspect. On whatever objects these rays fall, colour is produced; they have the same properties in every part of the solar system as on our globe, and therefore must produce colours of various hues on the objects connected with the remotest planets, according to the nature of the substances on which they fall. The azure colour of the sky was attributed by Sir Isaac Newton to vapours beginning to condense therein, which have got consistence enough to reflect

the most reflexible rays—that is, the violet ones; but not enough to reflect any of the less reflexible ones.

Climate and the season of the year have a considerable influence on the colour which the sky assumes. How blue it is in the hot summer months! how pale the blue of a clear winter's day, when the brown and bare branches of the trees show against it! But the darkest blue of our atmosphere is light when compared with that of hot climates, where it often assumes the colour of a deep rich indigo. How striking and delightful the changes of colour as viewed in our own country at the different times of the day,—those rosy mornings, the grey twilights of evening, and the splendours of the setting sun, round which the deep orange is shaded off into the most delicate yellow, which again melts and glides into the pale blue towards the east!

A very striking phenomenon, called the Aurora Borealis, or Northern Daybreak, so named, because it usually appears at or near the north, and presents a light somewhat like that which precedes sunrise, is often beheld in the sky. The Esquimaux and Greenlanders, and all such as dwell in the Polar regions, would indeed be very badly off, if it were not for the beautiful atmospheric appearances which illuminate their parts of the earth, during the winter months,

when the sun never rises to them above the horizon. In these regions there are seldom intervals of many hours that are not blessed with these meteors, which occur in a never-ending variety of form, colour, and intensity. They generally have a tendency to the shape of an irregular arch, one side being constantly much better defined than the other, the ragged side also sending out brilliant coruscations, which seem to terminate in the sharpest points.

The aurora borealis has been observed in almost every part of the world, although the frequency of its occurrence has varied very remarkably from one period to another. In our own country it often appears, but not nearly with the brilliancy or the frequency that it does in more northern regions. Its most beautiful form is called the Corona; being a luminous ring for the most part seeming to be just overhead, with long distinct rays, very slender, but extremely bright, shooting from it all around. It generally lasts but for a few seconds, and then appears to burst, scattering itself in all directions. Usually the stars shine through the aurora; and that the phenomenon is atmospheric, and not astronomical, has been presumed from the diurnal rotation of the earth producing no effect upon its apparent position. Mr. Dalton concludes its average height to

be about 100 miles. It has been placed by various philosophers above the atmosphere, and Euler supposed it to be at the height of more than a 1000 miles above the earth. It is still a question whether the aurora borealis is accompanied by any noise.

The position of this phenomenon has, in a majority of cases, been rather towards the west than the east, and it is more frequently seen in calm than in windy nights. Among the great variety of detached remarks which have been made upon its attendant circumstances, the following may be noticed :—there is always a copious deposition of dew during its appearance; in the English channel a hard gale from the south or south-east may be expected within twenty-four hours; and in northern climates very brilliant instances frequently succeed a sudden thaw after extremely cold weather. Still, the aurora must rather be looked upon as a phenomenon well worth observing, than as one which has as yet been well observed. The most reasonable and best modern theory, with respect to the cause of the phenomenon, seems to be, that it is the effect of electric fluid playing about, so to speak, and diffusing itself in the upper regions of the atmosphere, where the air is very thin.

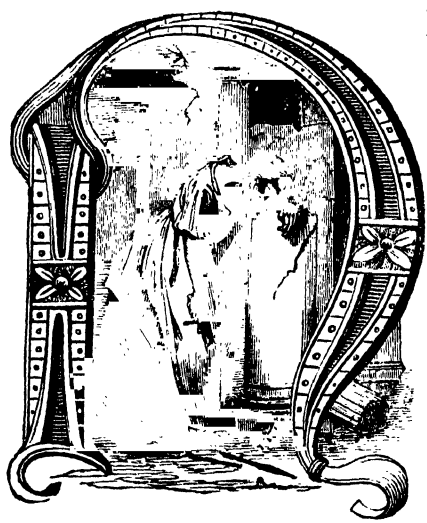
Numerous are the optical appearances and delusions of the atmosphere. Among such phenomena

may be mentioned shooting stars, or "November meteors," which have in late years excited much attention. These bodies appear to be of different magnitudes, and even of various forms. In general they seem to be globular, continuing visible only for a few seconds, and moving with great velocity. Their course is on some occasions in a straight line, and on others curvilinear, rendered more distinct by the tail or luminous train which they leave behind them; and before disappearing they are sometimes separated into several smaller bodies, accompanied by an explosion resembling thunder, more or less loud according to their magnitude or distance. It was long supposed, and seems now to be proved by satisfactory evidence, that these explosions are followed by a shower of solid bodies of a stony or metallic substance, some of which have even appeared luminous in their descent after the explosion, and have been taken up before they had time to cool. This last phenomenon, however, is of comparatively rare occurrence. Thousands of small meteors, as various in magnitude and brilliancy as the fixed stars appear to us, have been seen in all seasons, and almost in every variety of weather, unaccompanied either with explosions, or the decomposition of solid substances.

The most astonishing multitude of shooting stars on record, we believe, appeared in the night of the

13th November, 1833, being seen over nearly the whole of North America. They came from all parts of the sky and it was calculated that 36,000 must have appeared every hour for seven hours successively; at one time being, as described, half as thick as the flakes in a fall of snow. There have been, as in other cases, many vague and fanciful notions entertained with regard to the origin and nature of these bodies. Of the theories that seem to deserve attention, that which has ascribed these meteors to certain vapours arising from the earth, and becoming ignited in the higher regions of the atmosphere, may be mentioned. This hypothesis, however, appears to be very inadequate to account for all the phenomena already glanced at belonging to these meteors. Another theory is, that these bodies may derive their origin from a nebulous body which revolves round the sun, and which, in certain parts of its course, comes very near the orbit of the earth, so as to be within its attractive power; and also, that in November our globe passes near the orbit in which such nebulous matter or fragments move. There are men of great name who have recently lent their countenance to this hypothesis, regarding what are called the shooting stars as being of an astronomic, rather than of an atmospheric, origin.

AEROLITES, OR METEORIC STONES.



EXT, as to meteoric stones, which are bodies that have fallen on the earth from the sky, and are called *aërolites*, from two Greek words, signifying atmosphere and a stone. Historical records exist from very remote antiquity, and numerous writers in all ages have mentioned instances, of the remarkable phenomenon of stony bodies having been seen to fall from the upper regions; yet, till within the last half century, all such accounts were treated as tales of the ignorant and superstitious; nothing perhaps being more vain than the incredulity with which such numerous reports were received by the learned in Europe, who denied the existence of aërolites, merely because they had

not seen them,—because such bodies were inconsistent with the preconceived notions, or not corroborated by the experience of the laws of nature, which the philosophers possessed and promulgated. It must, indeed, be admitted, that few things are more calculated to puzzle a person than to account for large fragments of compact rocks proceeding from regions above the clouds. These stones sometimes fall during a cloudy, and sometimes during a clear and serene, atmosphere; sometimes they are accompanied with explosions, and sometimes not. The following accounts, selected from respectable authorities, of the circumstances and facts connected with the fall of aërolites, will convey some idea of the phenomenon, not only as attending the instances specified, but in most other cases of which a circumstantial description has been preserved.

On the 19th of December, 1798, about eight o'clock in the evening, a very luminous meteor was observed in the heavens by the inhabitants of Benares, and the parts adjacent, in the form of a large ball of fire; it was accompanied by a loud noise resembling thunder, which was immediately followed by the sound of the fall of heavy stones. All this was taken notice of by several Europeans, as well as natives. On examining the ground, it was observed to have been newly torn up in many places, while

these stones were found to be of a peculiar appearance, most of which had buried themselves to the depth of six inches. One of the stones, of about two pounds weight, fell through the top of a watchman's hut, close to which he was standing, and went to the depth of several inches in the floor, which was formed of consolidated earth. The form of the more perfect stones appeared to be of an irregular cube, rounded off at the edges; but the angles were to be observed on most of them. At the time the meteor appeared, the sky was perfectly serene, not the smallest vestige of a cloud had been seen since the 11th of the month, nor were any observed for many days after. It is well known that there are no volcanoes on the continent of India, and, therefore, the stones could not derive their origin from any such source; and no stones have been met with, in that part of the world, which bear the smallest resemblance to those now described. The meteor was seen in the western part of the hemisphere, and was only a short time visible. The light from it was so great, as to cast strong shadows from the bars of a window upon a dark carpet, and it appeared as luminous as the brightest moonlight.

On the 13th of December, 1795, a stone, weighing fifty-six pounds, fell near Wold Cottage, in Yorkshire, at three o'clock of the afternoon. It penetrated

through twelve inches of soil and six inches of solid chalk rock, and in burying itself had thrown up a large quantity of earth to a great distance. As it fell, a number of explosions were heard, which sounded at the adjacent villages as of great guns at sea; but at two adjoining hamlets, the sounds were so distinct of something passing through the air to the residence of Mr. Topham, that several people came up to see if anything extraordinary had happened at his house. When the stone was extracted, it was warm, smoked, and smelt very strong of sulphur. The day was mild and hazy, but there was no thunder or lightning the whole day. No such stone is known in the county, and there is no volcano nearer than Vesuvius or Hecla. The constituent parts of this stone were found exactly the same as those of the stones brought from Benares.

On the 26th of April, 1803, at one in the afternoon, an extraordinary shower occurred at L'Aigle, in Normandy. The sky was serene, with the exception of a few light clouds, when a rolling noise, like that of thunder, was heard, and a fiery globe of uncommon splendour was seen, which moved through the atmosphere with great rapidity, from south-east to north-west. Some moments after, there were heard at L'Aigle, and for thirty leagues round in every direction, loud explosions, which lasted from five to

six minutes, resembling the sound of cannon and musketry, followed by a long-continued noise, like that of many drums. The meteor from which the noise proceeded, appeared not so much like a ball of fire, as a small rectangular cloud, which, during the phenomenon, seemed not to move; but the vapour of which it consisted, was sent out after each explosion, in all directions. Throughout the whole district over which the cloud hung, there was heard a hissing noise, like that of a stone from a sling, and a vast number of mineral masses fell to the ground. Above two thousand were collected, and they varied in weight from two drachms to seventeen pounds and a half. When examined, these stones were all found to contain silica, magnesia, iron, nickel, and sulphur, in various proportions.

Several hundreds of instances might be produced of large masses and showers of stones having fallen from the upper regions upon the earth, frequently with fatal effects to men and animals; for no rational person is now slow to put credence in the accounts of such phenomena to be found in old and ancient writers. These stones, although they have not the smallest analogy with any of the mineral substances already known, either of a volcanic or any other nature, have a very peculiar and striking analogy with each other. Iron is found in all, and in a con-

siderable proportion, partly in a malleable state, partly in that of an oxide, and always in combination with a greater or less proportion of the rare metal called nickel; the earths constituting the other ingredients. No new substance, however,—nothing with which we were not already acquainted, has ever been discovered in their composition. It is the manner of combination, that is quite unknown in the stones, the rocks, and the products of volcanoes, extinct or in activity, belonging to our globe. Aërolites, when taken up, soon after their fall, are extremely hot. They appear to have fallen from various points of the heavens, at all periods, in all seasons of the year, at all hours, in all countries, on mountains, and on plains, and in places far remote from any volcano.

The origin of this remarkable class of natural phenomena is involved in great obscurity, and very different theories have been proposed to account for them. By some they have been believed to be bodies ejected from distant volcanoes belonging to the earth, —a conjecture which is refuted by every circumstance connected with them. Again, that such solid substances, in large masses, sometimes several hundred pounds in weight, could be generated in the higher regions of our atmosphere, by any conceivable chemical process, is an opinion altogether untenable, and is now generally discarded, even by most of those

philosophers who formerly gave it their support. There is, in the first place, no ground for supposing, from any discoveries yet made in chemistry, that the elements of which these meteoric stones are composed exist in the atmosphere; and even if they did, the enormity of the volume of the atmosphere, attenuated and rarefied as it is at the great height from which the stones fall, which would be required to produce solid masses of the magnitude mentioned, places the conjecture beyond all credibility. It seems, indeed, to be absolutely certain, that these substances and bodies proceed from regions far beyond the limits of our globe. Being convinced of this, Dr. Hutton, La Place, and others of great name, conjectured that they were thrown out by the volcanoes in the moon, with such force as to bring them within the sphere of the earth's attraction. But, on calculation, it is thought to be impossible that there could be any force in such volcanoes to throw large masses of stone over a space of several thousands of miles. From a calculation of the difficulties attending this hypothesis, La Place was afterwards induced to change his opinion.

The theories which seem to be most consistent with all known facts and laws of nature, proceed on the supposition that these meteors are bodies moving in space, either accumulations of matter as originally created, or fragments separated from a larger mass

of a similar nature. On the conjecture that the bursting of a large planet was the origin of the small planets, Vesta, Juno, Ceres, and Pallas, we may trace a source whence meteoric stones may originate. The velocity of motion of the meteors is immensely great; so that the heat produced by the compression of the most rarefied air from the velocity of motion, may be probably sufficient to ignite the mass; so that all the phenomena may be explained, if the meteors which throw down stones with explosions be supposed to be small bodies, which contain combustible matter, moving round the earth in very excentric orbits. Or, again, the bursting of a large planet by an explosive force, would naturally throw out a vast number of comparatively small fragments, which, on account of that smallness, would be projected with very great velocity; and being thrown beyond the attraction of the greater fragments, might fall towards the earth. They may afterwards have revolved round our globe at different distances, and may, in certain instances, be struck by the electric fluid, and precipitated upon the earth, so as to exhibit all those phenomena which usually accompany the descent of meteoric stones. Though not unattended with difficulties, something in the manner indicated by these latter views, seems the most plausible hypothesis which has yet been formed on the obscure subject of aërolites.

THE STARRY FIRMAMENT AS SEEN BY A COMMON OBSERVER.

FTER sunset, on a clear evening, just as the first stars begin to twinkle, let the observer station himself on some open spot, whence a good general view of the heavens can be obtained. He will then perceive above and around him, as it were, a vast concave hemispherical vault gemmed with stars, apparently of various magnitude, of which the brightest only will first catch his attention in the twilight; and more and more will appear as the darkness increases, till the whole sky is spangled over with them. When he has awhile admired the calm magnificence of this glorious spectacle, the theme of so much song and so much thought,—a spectacle which no one can behold without emotion, or without a

longing desire to know something of its nature and purport,—let him fix his attention more particularly on a few of the most brilliant stars, such as he cannot fail to recognise again without mistake after looking away from them for some time, and let him refer their apparent situations to some surrounding objects, as buildings, trees, &c., selecting purposely such as are in different parts of his horizon. On comparing them again with their respective points of reference, after a moderate interval, as the night advances, he will not fail to perceive that they have changed their places, and advanced, as by a general movement, in a westward direction; those towards the eastern quarter appearing to rise or recede from the horizon, while those which lie towards the west will be seen to approach him; and, if watched long enough, will, for the most, finally sink beneath it and disappear; while others, in the eastern quarter, will be seen to rise as if out of the earth, and, joining in the general procession, will take their course with the rest towards the opposite quarter.

If he persists a considerable time in watching their motions on the same, or on several successive nights, he will perceive that each star appears to describe, as far as its course lies above the horizon, a circle in the sky; that the circles so described are not of the same magnitude for all the stars; and that those described

by different stars differ greatly in respect of the parts of them which lie above the horizon; some which are towards the quarter of the horizon which is denominated the south, (the observer is supposed to be stationed in some northern latitude,) only remain for a short time above it, and disappear, after describing in sight only the small upper portion of their diurnal circle; others, which rise between the south and east, describe larger portions of their circles above the horizon, remain longer proportionally in sight, and set precisely as far to the westward and south as they rose to the eastward; while such as rise exactly in the east remain just twelve hours visible, describe a semicircle, and set exactly in the west. With those, again, which rise between the east and north, the same law obtains; at least as far as regards the time of their remaining above the horizon, and the proportion of the visible part of their diurnal circles to their whole circumferences. Both go on increasing; they remain in view more than twelve hours, and their visible diurnal arcs are more than semicircles. But the magnitudes of the circles themselves diminish, as we go from the east, northward; the greatest of all the circles being described by those which rise exactly in the east point. Carrying his eye farther northwards, he will notice, at length, stars which, in their diurnal motion, just graze the horizon

at its north point, or only dip below it for a moment; while others never reach it, but continue always above it, revolving in entire circles round one point, called the pole, which appears to be the centre of all their motions, and which alone, in the whole heavens, may be at present considered immovable. Not that this point is marked by any star. It is a purely imaginary centre; but there is near it one considerably bright star, called the Pole Star, which is easily recognised by the very small circle it describes: so small indeed, that, without paying particular attention, and referring its position very nicely to some fixed mark, it may easily be supposed at rest, and be itself mistaken for the common centre, about which all the others in that region describe their circles; or it may be known by its configuration with a very splendid and remarkable *constellation* or group of stars, called by astronomers the Great Bear. He will further observe that the apparent relative situations of all the stars among one another is not changed by their diurnal motion. In whatever parts of their circles they are viewed, or at whatever hour of the night, they form with each other the same identical groups or configurations, to which the name of constellations has been given. It is true, that, in different parts of their course, those groups stand differently with respect to the horizon; and those towards the

north, when in the course of their diurnal movement they pass alternately above and below that common centre of motion before described, become actually inverted with respect to the horizon, while, on the other hand, they always turn the same points towards the pole. In short, he will perceive that the whole assemblage of stars visible at once, or in succession in the heavens, may be regarded as one great constellation, which seems to revolve with a uniform motion, as if it formed one coherent mass; or as if it were attached to the internal surface of a vast hollow sphere, having the earth, or rather the spectator, in the centre, and turning round an axis inclined to his horizon, so as to pass through that fixed point or pole already mentioned.

Lastly, he will notice, if he have patience to outwatch a long winter's night, commencing at the earliest moment when the stars appear, and continuing till morning twilight, that those stars which he observed setting in the west have again risen in the east, while those which were rising when he first began to notice them have completed their course over the spectator's head, and are now set; and that thus the hemisphere, or a great part of it, which was then above, is now beneath him, and its place supplied by that which was at first under his feet, which he will discover to be no less profusely furnished with

stars than the other, and bespangled with groups no less permanent and distinctly recognisable. Thus he will learn that the great constellation above spoken of, as revolving round the pole, is co-extensive with the whole surface of the sphere, being in reality to the observer nothing less than a universe of luminaries surrounding the earth on all sides, and brought into view in succession, when referred to the imaginary spherical, or concave surface, of which he himself occupies the centre.

There is, however, one portion of this concave surface or sphere, of which he will not thus obtain a view. As there is a position towards the north, adjacent to the pole above his horizon, in which the stars *never set*, so there is a corresponding portion, about which the smaller circles of the more southern stars are described, in which they *never rise*. The stars which border upon the extreme circumference of this portion, just graze the southern point of his horizon, and show themselves for a few moments above it, precisely as those near the circumference of the northern portion graze his northern horizon, and dip for a moment below it, to reappear immediately. Every point in a spherical surface has, of course, another diametrically opposite to it; and as the spectator's horizon divides his sphere into two hemispheres—a superior and inferior—there must of

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necessity exist a depressed pole to the south, corresponding to the elevated one to the north, and a portion surrounding it, perpetually beneath, as there is another surrounding the north pole, perpetually above it.

> "One pole rides high, one plunged beneath the main,
> Seeks the deep night and Pluto's dusky reign."

To get sight of this portion, the observer must travel southwards. In so doing, a new set of phenomena come forward. In proportion as he advances to the south, some of those stars and groups, which, at his original station, barely grazed the northern horizon, will be observed to sink below it, and set; at first remaining hid only for a very short time, but gradually, as he goes farther towards the south, for a longer part of the twenty-four hours. They will continue, however, to circle about the same point, holding the same invariable position with respect to it in the concave of the heavens among the stars; but this point itself will become gradually depressed with respect to the spectator's horizon; while, by the same degrees as the northern pole is depressed, the southern will rise, and the constellations surrounding it, come into view.

If he travel unceasingly southward, he will at length reach the imaginary line on the earth's surface,

called the equator, at any point of which, if he recommences his observations, he will find that he has both the centres of diurnal motion in his horizon, occupying opposite points, the northern pole having been depressed, and the southern correspondingly raised; so that, in this geographical position, the diurnal relation of the heavens will appear to him to be performed about a horizontal axis, every star describing half its diurnal circle above, and half below his horizon, remaining alternately visible for twelve hours, and concealed during the same interval. In this way, supposing a night of twelve hours' darkness to be possible at the equator, the whole sphere of stars will have passed in view of the observer.

Travelling still farther southwards and away from the equator, the southern pole of the heavens will become gradually elevated above the horizon, and the northern will at a corresponding rate sink below it; and when he arrives at a station as far to the south of the equator as that from which he started was to the north, he will find the whole phenomena of the heavens reversed. The stars which at his original station described the whole diurnal circles above his horizon, and never set, now describe them entirely below it, and never rise to him. Such are the general appearance and apparent motions of the starry heavens, as they present themselves to the eye

of a common observer. All the phenomena which have now been noticed must serve to impress the spectator, who has never paid any attention to the subject of scientific astronomy, with the conviction, that the whole celestial vault performs a revolution round the earth—carrying, as it were, all the stars along with it, in the space of twenty-four hours. But is it *really*, as well as *apparently*, as the supposed person imagines? One thing is certain, that if his conceptions be just and correct the multitudes of stars which are seen by the unassisted eye, nay, the tens of thousands more which are discovered by means of the telescope, vastly more remote than the twinkling luminaries which are visible to the naked gaze, must travel at an inconceivable rate of quickness, in order to accomplish their journey in so short a space of time. In fact, millions of the starry host, according to this view, behoved to move at the rate of *several thousands of millions of miles in the space of a second of time*, seeing that in proportion to the distances of any of these celestial bodies would be the rapidity of their motions. We cannot, however, admit, in consistency with the dictates of enlightened reason,—and assuredly not in accordance with the discoveries of science,—that the apparent diurnal movements of the stars are the *real* motions with which these bodies are impelled. The following are some

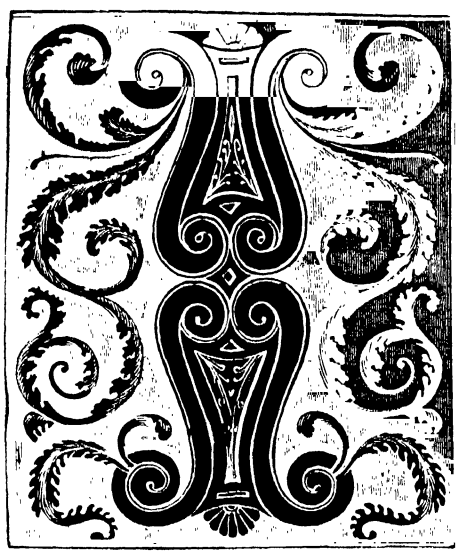
of the grounds which a thoughtful reasoner would take in an attentive consideration of the subject :—

First, such inconceivably rapid motions, on the part of the celestial luminaries, are altogether unnecessary to produce the effect intended, as supposed by the novice, viz., the alternate succession of day and night with respect to our globe; and it will be conceded that the Almighty does nothing in vain, but employs the most simple means to accomplish the most magnificent and important ends. Secondly, it is impossible to conceive that so many bodies, of different magnitudes, and at different distances from the earth, could all have the same period of diurnal revolution. Thirdly, such a rate of motion in the heavenly bodies would soon shatter them to atoms. Fourthly, there is no instance known in the universe of a larger body revolving around a smaller, in obedience to any natural law. Fifthly, the apparent motion of the heavens cannot be admitted as real, because it would confound all our ideas of the intelligence of the Deity. However much our conceptions of *Omnipotence* might be exalted by the supposition that the apparent was the real motion, there would be a sad distortion of our sentiments with regard to the attribute of *wisdom.* Is it possible to conceive that numberless millions of spheres, each of them vastly larger than our earth, and in all probability

the habitation of sentient and intelligent beings, have been appointed to move daily round an inconsiderable ball, when no end is accomplished by such a revolution, but what may be effected in the most simple manner? And for what end should the *apparent* be the *real?* That we poor mortals should gaze at them, and speculate till we arrived at the conclusion that however wonderful in power was the Architect of the Universe, his arrangements, at least with respect to the heavenly bodies, violated all our notions and sentiments of what is worthy of infinite intelligence! Impossible! Neither reason nor profound inquiry can ever carry us to this miserable conclusion. On the contrary, nothing in the entire range of demonstrable truths is clearer or better known, than that the system of the universe is one of beauty, harmony, and order, worthy of the infinite wisdom of Him who formed the plan of the mighty fabric, and who settled "the ordinances of heaven." A great man said that the Almighty's hieroglyphical characters are the unnumbered stars, the sun and moon, written on the large volume of the firmament.

"View the amazing canopy!
The wide, the wonderful expanse!
Let each bold infidel agree
That God is there, unknown to chance."

THE FIXED STARS.



N speaking of the fixed stars they shall be considered somewhat individually, and then as they have been classed by astronomers in mapping out the heavens, after the manner in which the surface of the earth has been divided, and the several sections named. With regard to the notions entertained by the ancients respecting the starry firmament, it seems only necessary to state that, in accordance with their most erroneous and defective theory relative to the earth being the centre of the universe, and of the motion of all the heavenly bodies, they supposed the stars to be planted in a hollow sphere, by the revolution of which they all turned round together in a day and night. These

by-gone speculators had formed no proper idea of the remoteness from our globe of even the nearest star; the principal service lent by them to the study of astronomy consisting of that method of grouping and classifying the stars, to be more particularly noticed below.

It is now the universal opinion of philosophers, and hardly ever questioned by persons of reflection, that the fixed stars, one and all of them, are vast luminaries resembling our sun, not only in respect of magnitude, but the worlds or planets which belong to the solar system; and that although they are reduced to mere points of light by their immeasurable distance from us, yet that, instead of being mere sparkling specks, having no other office or purpose but to gem our sky, and afford us pleasure, they are the centres of heat and light to worlds which surround them, each of which may be supposed to constitute a scene of life and action to myriads of beings. Thus much is certain, that although these wonderfully remote bodies which twinkle in our firmament may appear ever stationary in the spanning vault, they are found, upon closer inspection and study, to be subject to certain changes analogous to what take place on the part of our sun.

The total number of stars seen by the naked eye at once, on a clear night, has been estimated at not

above 2000 in number; but when the aid of the telescope is applied, the amount is enlarged in proportion to the power of the instrument, so that no possible limit can be named to the number of the starry host. The individuals which constitute the visible number vary in respect of brilliancy and the light they emit; those which are brightest being, as a general rule, held to be the nearest to us. But still,

> "Those sparks of light,
> The gems that shine in the blue ring of heaven,"

even such as are considered to be the least remote, are so immensely distant that the most powerful telescope affords not the slightest information with regard to either the actual distance or size of the orb: they have, indeed, even after the highest magnifying power has been applied, no measurable diameter. The most brilliant one of all the fixed stars, called Sirius, or the Dog-star, has been reckoned to give no more than 1-20,000,000th part of the light of the sun; so that supposing that this star resembled in every respect our central luminary, it must be distant from the earth not less than 1,960,000,000,000,000,000 miles. Although at one part of our globe's orbit it must be 190,000,000 miles distant at one period of the year from where it was six months before, yet no appreciable difference

can be discovered with regard to the distance of Sirius at the two periods, even by the astonishingly nice instruments now used by astronomers in the measurement of angles; and therefore the conclusion has been arrived at, that this brilliant star must be at least 19,200,000,000,000 miles distant, and, perhaps, greatly more. Take, however, the number named: in that case, it would take several years for its light to reach us, though light is known to travel at the rate of 192,000 miles in a second of time. Again, when Sir W. Herschel surveyed the firmament with his *forty feet* telescope, the mirror of which was *four feet* in diameter, such was the quantity of light or glare which the brighter stars shed upon his eye that he was obliged to withdraw from it. On one occasion, he says, "the appearance of Sirius announced itself at a great distance, like the dawn of the morning, and came on by degrees, increasing in brightness, till this brilliant star at last entered the field of the telescope with all the splendour of the rising sun, and forced me to take my eye from the beautiful sight."

The stars have been classified according to their different magnitudes; the degree of light emitted by them, and not their size, being meant. According to this classification there are stars which are said to be of the first magnitude, the second magnitude, and so

on, until the sixth degree is reached, as observed by the naked eye ; but astronomers, by means of their glasses, extend the division to more than double that number of gradations. A number of stars have long been known to undergo changes in respect of the degree of light they give ; the variations in not a few cases having been ascertained to be periodical, and occurring within definite periods ; these changes occupying different spaces of time, ranging from a few hours or days to many years. There is one star, viz., Algol, which decreases from the second to the fourth magnitude, and then increases to its greatest lustre,—the whole change occupying something less than three days. There is a star in the Swan which wanes from the sixth magnitude to entire invisibility, and then returns to its greatest brilliancy, in eighteen years. It is even ascertained that certain stars which were at one time visible, are not so now ; and there have been, at different periods, new stars, stars which were not previously discernible, yielding, however, only a temporary light, although for awhile with extraordinary brilliancy, but waning away, and at length leaving no trace behind. A star is recorded to have appeared between Cepheus and Cassiopeia in the years 945, 1264, 1572, which is supposed to be owing to periodic changes in the same star, with an interval of about 319 years. If

so, astronomers may look for its re-appearance in the latter part of the present century. So suddenly did it come into view last time, that Tycho Brahe, the celebrated Danish astronomer, returning one evening to his home from his laboratory, found a group of country people gazing at a star, which he was sure was not visible half an hour before. This was the star in question, and it was then as bright as Sirius, continuing to increase in brilliancy till it surpassed Jupiter, when brightest, being even visible at mid-day. In December of the same year it began to decrease, and in March, 1574, it had wholly disappeared. It is conjectured towards an explanation of the various phenomena now noticed, that a greater or less part of the periodical and occasional stars is not luminous at all; and that while, like the sun, they rotate on their own axis, their extinguished as well as diminished lustre is attributable to the dark portions being more or less turned to us. It is also conjectured that dark bodies of great magnitude revolve round the stars, so as to intercept part of their light.

There are not only stars which emit to us different degrees of lustre at different times, but a different *kind*. There are many instances where there is a variation of colours in the double stars, such as a red and green star being associated, and a yellow with a

blue. Even to the naked eye, especially in climes where the atmosphere is much more pure than with us, there is seen "one star differing from another in glory," owing to some unascertained circumstance in the constitution of the heavenly bodies.

Having made mention of *double stars*, there are now to be noticed a class of phenomena which seem to be still more remarkable than even the circumstances relative to the colour of the stars; for not unfrequently a group of two or more stars occur, these being so closely combined or situated that they appear to the naked eye as a single star, although they are distinctly and decidedly separated when viewed through glasses of considerable power. Now, it has been satisfactorily shown by Sir W. Herschel and others, that such a phenomenon as that of the double or *Binary Stars* arises not, in many instances, from any optical conjunction, or from their being situated in the same visual line as if the one star were behind the other, although, no doubt, such accidental positions may occur. Most frequently, however, two stars, when in actual proximity, are so according to a systematic and regulated union or order, that order being held by the most eminent natural philosophers to subsist through the agency of some general law, viz., that of mutual attraction.

It has been observed that the double stars move

round each other within certain periods, and also that the motion is sometimes in very elliptical orbits. There is, indeed, great variety in this department of celestial phenomena, the revolutions of some of the binary class occupying forty-three years, and others ranging from that period up to twelve hundred years. These very peculiar stars present a subject of great interest to the philosopher, were it but merely that they afford him the means of demonstrating the fact of the great law of mutual attraction not being confined to our own system, but that it extends its agency through the illimitable realms of space. What a field for speculation is also here presented as to whether one of these double stars ministers to the other as a sun,—whether both are suns,—whether the organised life, the beings which may be endowed with vitality that inhabit them, can endure a never-ceasing heat and light reciprocally lent.

Besides the combinations of two stars, there are others which are *ternary*, presenting the conjunction of *three* bodies. Still more complex systems have been discovered. Groups of four, and even of five have been observed to present such phenomena, as to give great probability to the conjecture of their being mutually related; nay, the same view has been carried out to the forty-four stars which form the group of the Pleiades. Rising very much higher, it

is now concluded by the most scientific astronomers, that all the stars distinctly visible to us really form part of one immeasurable and innumerable cluster, of which the boundary is formed by the Milky Way, our sun being, probably, situated not far from the centre of such a mighty host. It is also concluded, that while, by the law of mutual attraction, there would be a tendency of all the individual stars towards each other, and towards the centre of the entire cluster or mass, yet that such a tendency is counteracted by giving to them all a movement around that common centre of gravity, analogous to that which preserves the planets from being drawn out of their paths towards the sun.

Perhaps the most magnificent department of our star-system is known by the name of the Milky Way, just now noticed, being that broad luminous belt or arch, to be seen on a clear dark night, which stretches across the whole sky from horizon to horizon. The same delicate luminous cloud, or band of whitish lustre, is traceable through the southern as well as northern hemisphere, forming a complete circle surrounding our starry host at an amazing distance. Of this phenomenon the ancients formed the paltry notion that it was the milk spilt by the nurse of Mercury, and hence its name. This luminous arch seems, when viewed by the naked eye or super-

ficially, to be studded with distinct stars. However, when carefully examined by a powerful telescope, these stars form no part of such a belt, having it only as a background, so to speak, seen in the same direction. This phenomenon, when so closely observed, is found to consist of innumerable multitudes of very faint stars, and not of any vapour-like assemblage of diffused matter,—stars scattered by millions, like glittering dust on the general heavens.

> "A broad and ample road whose dust is gold
> And pavement stars, as stars to us appear
> Seen in the galaxy; that Milky Way
> Like to a circling zone, powdered with stars."

The average magnitude of the stars constituting the Milky Way is about the tenth or eleventh, and therefore their individuality baffles the perception of the unassisted eye. It will at once be believed, in accordance with the facts mentioned, that the number of stars which are thus crowded together must be enormous.

To conclude, with regard to the distances, sizes, and numbers of the fixed stars, let it be asked in the words of Sir J. Herschel, "for what purpose are we to suppose such magnificent bodies scattered through the abyss of space? Surely not to illuminate *our* nights, which an additional moon of the thousandth

part of the size of our own would do much better,—nor to sparkle as a pageant void of meaning and reality, and bewilder us among vain conjectures. Useful, it is true, they are to man, as points of exact and permanent reference; but he must have studied astronomy to little purpose who can suppose man to be the only object of his Creator's care, or who does not see in the vast and wonderful apparatus around us, provision for other races of animated beings. The planets derive their light from the sun; but that cannot be the case with the stars. These, doubtless, then, are themselves suns; and may, perhaps, each in its sphere, be the presiding centre round which other planets, or bodies of which we can form no conception from any analogy offered by our own system, may be circulating."

"And these are suns! vast, central living fires,
Lords of dependent systems, kings of worlds,
That wait as satellites upon their power,
And flourish in their smile. Awake, my soul,
And meditate the wonder! Countless suns
Blaze round thee, leading forth their countless worlds!
Worlds in whose bosoms living things rejoice,
And drink the bliss of being from the fount
Of all-pervading love. What mind can know,
What tongue can utter all their multitudes!
Thus numberless in numberless abodes;
Known but to Thee, blest Father! Thine they are,
Thy children, and thy care; and none o'erlooked
Of Thee! No! not the humblest soul that dwells

Upon the humblest globe, which wheels its course
Amid the giant glories of the sky,
Like the mean mote that dances in the beam
Among the thousand mirror'd lamps, which fling
Their wasteful splendour from the palace wall.
None, none escape the kindness of Thy care;
All compassed underneath Thy spacious wing,
Each fed and guided by Thy powerful hand!"

URANOGRAPHY.

NOTWITHSTANDING that the ancients had formed extremely mean ideas of the celestial bodies, they conferred an important service towards the study of astronomy, as shall immediately be seen, by their method of grouping and classifying the stars; having in their *Uranography*, or description of the starry host, formed similar divisions as in *geography*, or the description of the earth, for the purpose of fixing the place where any peculiar appearance is to be seen, or the star which is presenting certain movements and positions. Accordingly, under such a delineation, are all those arrangements which have been adopted for the artificial exhibition and nomenclature of the heavens, and

for working the mathematical problems connected with the celestial spheres. Thus, were it wished to make the situation of a comet generally known, which had become visible, the constellation or group of stars near which it was to be seen would be named, or even some particular star in that constellation, which is distinguished by a letter of the Greek alphabet, and when these are exhausted by means of a number. It is true, that the ancients in mapping out the heavens into a series of constellations, absurdly enough conferred names upon the groups, according as they conceived these groups to have a resemblance to the figures of demi-gods, men, animals, &c.; at the same time that they invented wild and extravagant fables with respect to the origin of each constellation. Nevertheless, modern astronomers retain most of the ancient terms, without, of course, paying any heed to the romantic dreams in which they had their origin, there being nothing more to be avoided in science than a confusion of names. There is, for example, a number of stars in the northern part of the heavens, which have been artificially grouped together under the name of *Ursa Major*, or *the Greater Bear*, and which has been besides variously designated, *Charles's Wain*, in honour of the illustrious French monarch, Charlemagne, and *the Plough*. The figure immediately to be introduced, represents the constellation

of Orion, being the imagined representation of a man, from the fable of an early Greek semi-divine hero of that name. This is one of the most splendid of the

constellations, on account of the number of large stars which belong to it, particularly the three that dazzle obliquely in the girdle, two considerably higher in the shoulders of the figure, and other two considerably below, one being in the foot, and the other

in the knee. There are other stars of great lustre in this group, such as those in the dagger, and also those in the head of the lion.

Some of the names conferred on the constellations are of Chaldean origin, bestowed long before the commencement of the Christian era; others are borrowed from the Arabs; and others again are of modern date, created particularly to distinguish those stars of the southern hemisphere, with which the ancient astronomers were not acquainted, and which were first observed by the adventurous mariners of the fifteenth century. Let it, however, be continually understood, that although for convenience it is most proper to arrange the starry host into groups, the individual members of any of those groups are not at all in near proximity to each other, but in reality at enormous distances, at the same time that there is no sort of uniformity with regard to their remoteness from us.

There are twelve of the constellations situated in that region of the heavens which is opposite to the ecliptic in the terrestrial globe; or, which comes to the same thing, if the plane of the planetary motions reached to the stars, it would strike the region occupied by these groups or assemblages of stars. This part of the celestial globe is called the *Zodiac*, and these groups have received the titles of the

Zodiacal Constellations, or *Signs of the Zodiac*; the Zodiac being a zone or belt of stars above and below the sun's path, extending eight or ten degrees on each side of the ecliptic. It is divided into twelve parts, each of thirty degrees, which are termed, as already said, the signs of the zodiac. The names given to the signs, and the particular days in which the sun enters them, are these; Spring signs:—*Aries*, the Ram, 21st March; *Taurus*, the Bull, 19th April; *Gemini*, the Twins, 20th May. Summer signs:—*Cancer*, the Crab, 21st June; *Leo*, the Lion, 22nd July; *Virgo*, the Virgin, 22nd August. These are termed the *Northern Signs*, because of their being north of the equator. Autumnal signs:—*Libra*, the Balance, 23rd September; *Scorpio*, the Scorpion, 23rd October; *Sagittarius*, the Archer, 22nd November. Winter signs:—*Capricornus*, the Goat, 21st December; *Aquarius*, the Water-bearer, 20th January; *Pisces*, the Fishes, 19th February. These are termed the *Southern Signs*, because of being south of the equator. The following few doggrel lines may serve to imprint the list upon the memory:—

The Ram, the Bull, the heavenly Twins,
And next the Crab the Lion shines,
The Virgin and the Scales,
The Scorpion, Archer, and the Goat,
The Man that holds the watering-pot,
And Fish with glittering tails.

In a preceding section the starry firmament has been described as it presents itself at certain times to a common observer. There is an individual in that mighty host which is called the *Pole Star*, and which, to an ordinary observer, never seems in our northern latitude to vary its position, all the others appearing to circulate around it as a fixed and common centre. This star, however, is not exactly at the polar point, but is named the Polar Star because it is the nearest bright one to the north pole of the heavens. Now, let us suppose ourselves observing the northern regions of the heavens, say about the beginning of November, at eight o'clock in the evening, when the sky is clear, and beautifully studded with stars,—we shall then discover *Ursa Major*, not far from the northern part of the horizon, being near the lowest part of the constellation's course: it is most commonly recognised by means of seven very bright stars belonging to it, four of them forming an irregular square, and three stretching out into a kind of curve. Two stars of the square, the one named *Dubhe* and the other *Merak*, are termed *the Pointers*, because they always point towards the polar star, which in fact is the first bright star in a line with the pointers, a coincidence which will always distinguish that central star. At different hours of the night supposed, the constellation will be seen to have changed its place in the heavens, as also,

if viewed at different periods of the year, it will have different positions at the same hour, but always maintaining a steady relation in respect of the pole star, which forms the extremity of the tail of *Ursa Minor*, or the *Lesser Bear*, which likewise presents seven stars, arranged very much according to the order of those in *Ursa Major*, although in a reverse manner, being also not at all so conspicuous. Suppose we are surveying the southern, eastern, and western regions of the heavens, at the commencement of January,—say about nine o'clock in the evening,—we shall then discover the *Seven Stars*, a little westward of the meridian, at a high elevation. *Aldebaran*, or the *Bull's Eye*, is next to this group, on the east, being a little lower, presenting a ruddy star of the first magnitude, belonging to the constellation *Taurus*. To the south-east of the Bull's Eye, a good way below it, is the very remarkable and brilliant Orion. This constellation has ever been an object of admiring observation, especially the three stars which form the belt, known by the several names of "the Three Kings," "the Yard," and "the Lady's Elwand." In Job we read of them as "the bands of Orion." It may here be noticed that in the same portion of Holy Writ, we read of Arcturus and the group of small stars called the Pleiades, that book being one of the earliest portions of Scripture, composed probably

at least three thousand years ago. South-east of Orion, Sirius is situated, but at a low position. This most brilliant of the stars, as viewed by us, is a member of the *Great Dog*. Procyon is to north-east of Sirius, but at a higher position. This is also a bright star, and belongs to the *Little Dog*. At a much higher elevation, and north of Procyon, are the lustrous stars named Castor and Pollux, in the constellation Gemini. Next, survey the heavens about twelve o'clock of the same night, and obvious alterations will have by that time occurred in respect of the situations of the same constellations and their individual members, which have now been named. The *Seven Stars* will be found about half-way between the meridian and western horizon, followed by *Aldebaran*, which has now got a good way past the meridian to the westward. Westward of the meridian will also be found Orion, while Sirius, instead of being in the south-east, is almost directly south. Procyon, as well as Castor and Pollux, are near to the meridian, and consequently much more elevated than at the former period of the night. From these instances, and from many more which might be adduced, it is manifest that the numerous constellations in the regions of the heavens that are eastern, southern, and western, all apparently move from east to west, in the most regular and constantly

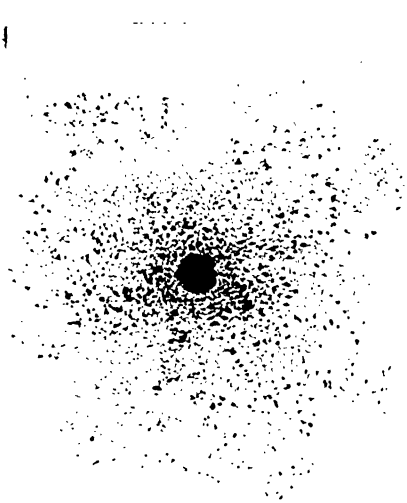
the same order. But not to pursue this branch of the subject further in an elementary work, it may be sufficient to add, that were the spectator stationed in other quarters of the earth than that of our northern latitude, the heavens, with the multitudinous stars, would present considerably different aspects from those which have now been noticed ; and that, for example, were he to take his stand under the equator, the whole starry host of the firmament would appear to be coursing their way from east to west, and to rise and to set, without a single member of any group describing a complete circle above the horizon, in the manner that not a few of them proceed, as beheld in certain latitudes; the northern, for instance.

REMOTE STAR CLUSTERS.—NEBULÆ.

O limits can be set to the star-systems, even after passing beyond all that has yet been said of the fixed stars and the milky way of our own cluster, not only as viewed by the naked eye, but by the most powerful telescopes, revealing millions of millions of orbs, each probably a sun of similar magnitude and influence with that which illumines our earth, and probably also attended by a number of worlds, like the planets of the solar system, revolving round in obedience to grand universal laws of nature. Indeed, what vastness and multiplicity of suns, with their attendant planets and their satellites again, which man's arithmetic or mind ever reached, in way of calculation, can form more than an item in the infinity of space and creation? All human con-

ception here falls immensely short when endeavouring to fathom the works and ways of the Eternal,—inconceivable as these are in other instances—in so many other astronomical cases. But to speak more directly of what are called the remote star-systems or clusters, it is a fact that the telescope has reached and descried far beyond the bounds of our starry firmament, very many other similar systems, each suspended in some tolerably defined form, in the boundless empyrean, and each resolvable, although not exactly into stars, yet into what has strikingly been denominated *star-dust*—an assemblage of minute brilliant particles, each of which would very probably be discovered to constitute a distinct star, if still more powerful glasses were directed towards them than have yet been constructed. In different regions of the heavens, even when the eye is unassisted, there may be descried luminous spots presenting something like stars encompassed by a bright halo, or comets, which have no tails; but that they are not of a cometic character is known, were it merely from the fact of their fixed positions. Under the more perfect instruments, in not a few instances, such luminous spots are seen to be composed of clusters of stars, the clusters having more or less of the globular shape. By attentively examining through the most improved telescopes these star-systems, in the direction of the heavens which

has fewest stars belonging to our system, and, therefore, is clearest for observation, comparatively distinct views are obtained of the more remote firmaments. It is manifest that even in the comparatively limited fields which can be scanned by us, very large numbers exist of such systems as are now more particularly under consideration, for the amount of light which each individual star of the clusters transmits, is far less than that of the smallest stars of the *Milky Way*. More than a thousand have been seen in the northern hemisphere alone. The appearance of one of these remote clusters, termed *Nebulæ*, being, perhaps the most beautiful of the multitude that has yet been subjected to careful examination, is to be found in the constellation *Hercules*. This example is so brilliant that it is discernible by the naked eye; while by means of an ordinary night-glass, it resembles a small round comet. *Nebulæ* is the term applied to these remote groups, because of their cloudy appearance, although



when scanned through highly magnifying instruments, the mass separates into compound parts, there being a crowding together of the star-dust towards the centre. The above accompanying figure will serve to convey some faint idea of the group, now particularly alluded to. It would be a most vain thing to attempt reckoning up the number of stars which compose any one of these *Nebulæ*. It is certain, however, that many of them cannot contain less than from ten to twenty thousand, crowded into a space, the extent of which does not appear to us larger than a tenth part of that which the moon covers.

Various are the forms of the *Nebulæ;* but so far as has yet been discovered, these forms have generally the aspect of some sort of regularity, frequently constituting spherical groups, and, what is very remarkable, bearing a pretty close resemblance to that which it is now generally held by astronomers to be the form of our own star-system ; or a flattened mass, with a brilliant annular exterior, parting into two at one part. Other clusters present extraordinary, and even startling forms, such as that of a crab, an anchor, &c. There is a remote star-cluster (30 Doradus) in the *Magellanic Clouds* of the southern hemisphere—which are so named after the celebrated voyager who first noticed them—that has been described by Sir J. Herschel, as "consisting

of a number of loops united in a kind of unclear centre or knot, like a bunch of ribbons disposed in what is called a true-lover's knot." "How lost are we in mute astonishment," observes a writer, whose eloquence is inspired by the transcendant science of which he speaks, "at these endless diversities of character and form! But in the apparent aim of things near and around us, we may perhaps discern some purpose which such variety will also serve. It seems the object or result of known material arrangements, to evoke every variety of creature, the condition of whose being can be made productive of a degree of durability; and perhaps it is one end of this wonderful evolution of firmaments of all orders, that there, too, the law of variety may prevail, and room be found for unfolding the whole riches of the Almighty." Three circumstances are particularly important with regard to the character and position of the Nebulæ,—they constitute systems which are assuredly distinct from our starry firmament,—the distance of the nearest of them is amazingly farther off than any of the individual stars in our stellar system, some of them being removed myriads of times more remotely than Sirius; and, again, their relative distances in regard to themselves or each other, is, in many cases, perhaps in all, according to a scale at least as grand and

immeasurable as that which characterises the stars of our own cluster. It is a remarkable and instructive fact, that not only does every improvement of the telescope bring into view distinct clusters which never before were seen or detected, but resolves others into distinct stars which had previously been discovered, but were irresolvable. Would it not then be most preposterous to conclude that we have by the latest and profoundest discoveries into the depths of space reached the remotest cluster, or the confines of the universe, or even that man by the utmost artificial aid that he can ever invent or construct, is to reach the remotest group,—the boundaries of God's material creation? Would it not be a far more becoming and reasonable thought, were we to suppose that, if stationed at the remotest point to which the telescope has yet conducted the vision of man, or ever shall conduct it, we should still be only in a condition to re-commence the work of making a survey over new and no less inconceivably remote clusters than had from the earth been descried? Another reasonable and soul-elevating view is, that system and definite arrangements prevail among the whole assemblage of clusters,—that there is nothing like confusion or a random scattering of the millions of suns that are suspended in space, governed, most probably, by the operations of the same law that

keeps the planets in their path. Who shall dare to set a limit to the length and breadth,—the height and depth—of Almighty power, that has filled all space with creatures, endlessly diversified every way? "Our own planetary system," observes the writer in the *Popular Cyclopædia of Natural Science*, "comprising, as it does, a sweep of nearly six thousand millions of miles in circumference, is but a speck, almost immeasurable on account of its minuteness, when viewed from the nearest of those luminaries which sparkle in our skies, like brilliants studding the dark mantle of night. The whole assemblage of those luminaries, bound together by a common tie, and encircled by the glowing zone whose distance reduces its brilliance to the soft and gentle light of the Milky Way, constitutes an isolated cluster, which would appear but as a luminous speck in the firmament when seen from even the nearest of similar groups, and but as a filmy spot when viewed even with the most powerful telescopes from the more remote. And all these clusters are themselves part of one great system, bound together by common ties, glowing with the same light, their movements regulated by the same laws,—and thus proclaiming to the mind of man the unity of creative design. And how is this conviction strengthened, when we find that even this is not

the highest point from which we can survey the universe,—that we can look even beyond that vast system of which we form so insignificant a part, and discern the impress of that same design in what we might almost term a different universe,—so vast must it be,—so completely does it seem isolated from our own! And even this is probably but one out of many formed upon the same plan, yet each differing from the rest, as this from ours." Infinite Wisdom as well as infinite Power must have called all this marvellous harmony,—this consummate beauty and absolute perfection,—into existence. What Love and Beneficence to bestow upon man the longings and capacity of preparing himself for entering upon an immortal state, where, disencumbered of a thousand obstructions which his present condition throws in his path, endowed with more acute senses and with higher faculties, he shall drink deep at that fountain of wisdom, for which the slight taste obtained on earth has given him so keen a relish!

"There is a land where everlasting suns
Shed everlasting brightness,—where the soul
Drinks from the living streams of love, that roll
By God's high throne! Myriads of glorious ones
Bring their accepted offering! Oh, how blest
To look from this dark prison to that shrine,
T' inhale one breath of paradise divine,
And enter into that eternal rest
Which waits the sons of God."

Well may we exclaim in the following eloquent words, "if the eye of man is here permitted to behold such dazzling wonders,—if his mind can soar into such depths of space, and grasp such immensity of time,—what will be the world which *eye* hath not seen, and which the human imagination cannot conceive? What will man be when he is perfected and become as the angels in heaven?"

THE NEBULAR HYPOTHESIS.

EARER as we approached the last of these pages, the higher is the mind carried in its contemplation of omnipotence and divine goodness; at the same time that speculation takes more lofty flights, being in the most natural manner prompted and enabled to soar into still further regions of speculation, forming hypotheses which may serve to explain phenomena which at the time transcend our knowledge, and otherwise altogether baffle the powers of our reason, even greatly outstripping the most adventurous imaginings. Such is the nebular theory, which at present, however, can only be called a very probable hypothesis,—that is, a theory which requires to be confirmed by the results of further inquiries; but, from what has of recent years been developed,

in consequence of improvements in the telescope over what had ever before been accomplished, and hardly dreamt of, from the discoveries which are already owing to the genius of Lord Rosse, how much greater advances may ere long be realised in man's acquaintance with the structure of the heavens, and the laws which govern the history and movements of the celestial spheres! The telescope of the nobleman who has just been named, has in a very short time actually lent such admirable services, that these amply sustain the expectation of an approaching wide extension of the bounds of man's universe, and of an analysis of its parts, far minuter and more accurate than has ever been attainable before. How different was the Astronomy of but a recent period, which was limited to discussions concerning the motions of the small bodies which attend our sun, and which looked at the farther heavens only with vague and incurious eye—content to admire their beauty, and confess their mystery—to what it really is at the present day! But of the hypothesis in question:

Astronomers for a number of years had been directing their attention to certain peculiar appearances which seemed to be within the limits of our starry firmament, and which, it is now believed, have a different character from that of the *Nebulæ* we have

before been speaking of, although the same general name has been applied to the whole of these cloud-like phenomena. The nebulous patches now to be spoken of, still remain altogether irresolvable, even when the most powerful instruments yet known are directed towards them; and from this and other anomalous circumstances, they are now held to consist, not of clusters of completely formed stars, but of vast masses of self-luminous matter, in a condition of greater or less diffusion,—frequently but films or vapours floating in space, like the most delicate clouds distinguishable in the flood of light sent upwards in a calm sunset; the milky light being spread over a large space so equably that scarcely any peculiarity of constitution or arrangement can be perceived. These may be called perfectly diffused, amorphous, or shapeless nebulosities. There are many others, however, in which structure, as governed by law, has begun to appear, having made, it is supposed, certain advances to completed forms, being in various stages of progression, and presenting a regular series of gradations. Now these facts and circumstances, together with other observed phenomena, have led to the hypothesis, that such nebulous masses are gradually undergoing a change, by the conversion of the filmy matter or luminous vapour into a condensed and solid state, so as that this body is continually

increasing in bulk, while the luminous atmosphere

is diminishing in extent. The theory goes further

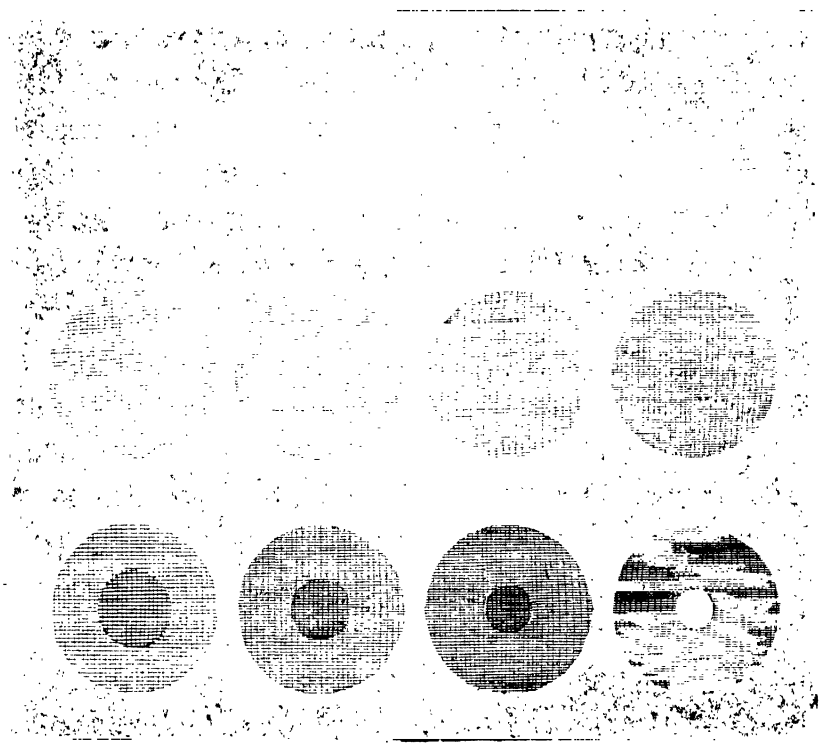
than this, holding the probability to be great, that all the solid masses constituting our own and other clusters, were originally in the condition of this luminous vapour, this nebulous matter,—that the whole of the stellar bodies sprang from the universe or bosom of chaos, this chaos being the vague and shapeless mass of filmy substance that was everywhere.

According to the nebular hypothesis, as has already been stated, the luminous vapour is characterised in its first or rudest state by great diffusion. Parting from these perfectly diffused and ill-shaped nebulosities, structure as governed by law, observes Professor Nichol, begins to appear, its first visible indications being very emphatic. The figure here introduced, for example, presents a winding nebulosity, exhibiting a congregating or condensing of the filmy matter in two distinct places, which look like bright nuclei, surrounded by a comparatively dark ring, just as if they had been formed by an actual condensation of the diffused matter. This is no anomalous appearance, adds the learned doctor; for in every case the seeming commencements of structure are of the same kind, nothing being anywhere met with like a dispersion of the luminous vapour, or indication of a dispersive power; on the contrary, there is never a departure from the character due to

their supposed orgination in a condensing principle, under the controul of the law of universal attraction.

The single nebulæ characterised by structure have a variety of forms, some being oblong, with distinct condensation towards the centre. But a vast proportion of them, according to Sir J. Herschel's catalogue, are round, and decidedly inclined to a spherical figure. That these are neither of a conical nor cylindrical form is concluded from this circumstance, that, if they were of such a shape, they would not all so lie in regard to our line of vision, as constantly to present their circular sections. The sphere, indeed, is the figure which is naturally assumed by masses, whose particles mutually attract each other; so that, as argued by Dr. Nichol, on the principle that the globular shape of the rain-drop is accepted as a common illustration of the all-prevalence of gravity, and as also the sphericity of the planets is held to confirm the same important law, the same tendency in the nebulæ must be taken as a weighty argument in support of the hypothesis under consideration. But it is the mode of the distribution of their light, continues the same writer, which lends still greater confirmation to the theory; for on the very first glance, these nebulæ present phenomena which are connected with central influence; the illumination not only being in all cases greatest at the centre, but

if in any nebula a circle of any radius be described around the centre, the illumination will be found of the same intensity at every part of its circumference.



There is something still more remarkable in relation to these nebulosities; for this most important fact characterises them, that there is a wonderful gradation in the intensity of the central light, ranging from absolute vagueness to distinct structure. The accompanying representation speaks to the eye, and

is more valuable than pages of description; each figure in that woodcut setting before us not an individual, but the type of an extensive class. Even after the distinct and progressively more defined structures have been observed, as represented in the engraving, there are further gradations, more and more brilliant instances; until, at length, a star is found perfectly organised, with a mere burr or mist around it.

It ought to be mentioned that the number of nuclei in distinct nebulæ is variable, and that it is not unfrequent to meet with double nuclei which exhibit all the varieties of distance, position, and relative brightness, with their counterparts, the double stars. Is it not highly probable that these are binary stars in process of formation? Assuredly, such double nuclei, with their regular gradations in their intensities, the points of light growing brighter, while the vacancies or dark circles around the points are marked with more distinctness, offer most interesting subjects for future observation and inquiry.

It is a startling idea, that all the masses and luminaries,—all those suns or stars, with the planets which spangle the heavens, had their origin in a diffused nebulous matter, portions of which still remain visible to us; and that the definite form of these myriads upon myriads of worlds was gradually

acquired by the progressive condensation of this filmy and attenuated substance, first into some sort of fluid, and then into a solid ; nay, that this process of condensation is still in progress, having reached greater or less advances towards completed and perfected forms, in perhaps myriads upon myriads more of instances within the regions of illimitable space. The hypothetic idea is at least grand, and, if possible, it gains upon our wonder, when it is stated that the single law of attraction upon amazingly diffused matter, may have produced all those completed worlds, and that the same law is at this moment in active operation towards perfecting other stellar spheres within the realms where the materials of the universe have their existence. True, we have as yet no certain knowledge with regard to the condition, the constitution of the nebulæ, or of the changes they undergo. Perhaps such knowledge shall never be obtained ; and yet the hypothesis which seems at first so startling, may, nevertheless, be true : for the more it is considered and examined, its probability, whether tried according to astronomical observation, or mathematical reasoning, gathers strength, being consistent with the analogies and harmonies which prevail throughout the works and ways of the Creator.

But where, after all, is the mystery here more perplexing than in numberless more familiar cases ?

Are we confounded by the length of time that must have sped, or by the transformations and changes that must have taken place, according to the theory under consideration, ere, for example, the solar system could have been brought to its present state? "Time and change," Babbage has observed, "are great only with reference to the faculties of the beings which note them. The insect of an hour, which flutters during its transient existence in an atmosphere of perfume, would attribute unchanging duration to the beautiful flowers of the cistus, whose petals cover the dewy grass, but a few hours after it has received the lifeless body of the gnat. These flowers, could they reflect, might contrast their transitory lives with the prolonged existence of their greener neighbours. The leaves themselves, counting their brief span by the lapse of a few moons, might regard, as almost indefinitely extended, the duration of the common parent of both leaf and flower. The lives of individual trees are lost in the continued destruction and renovation which take place in forest masses. Forests themselves, starved by the exhaustion of the soil, or consumed by fire, succeed each other in slow gradation. These periods again merge into other and still longer cycles of geological change, which occasions the submersion of the forest, the conversion of its living trunks into their stony resemblances,

and the subsequent upheaving of these as portions of the continents and islands of a new surface." In like manner, "when the birth, the progress, and the history of sidereal systems are considered, we require some other unit of time than even that comprehensive one which astronomy has unfolded to our view. Minute and almost infinitesimal as is the time which comprises the history of our race, compared with that which records the history of our system, the space even of this latter period forms too limited a standard wherewith to measure the footmarks of eternity."

Nothing starts suddenly into existence; everything grows, and is gradually developed. The thing which confounds us with regard to the nebular hypothesis, is not any intrinsic difficulty or dissimilarity; we are not rendered incredulous by the nature, but overwhelmed by the magnitude of the work, the stupendous changes, and the lapse of time. Time, indeed! Why *time* has nothing to do with the subject, for we are considering of the operations of *One* who is above all time! We are speaking of the handiwork of the *Eternal!* We are venturing to speculate concerning the will of Him who equally directs and superintends the growth of the gnat and of a firmament with all its mighty worlds, each, most probably, teeming with life!

It becomes a fair and important matter, when endeavouring to test the soundness or even probability of the nebular hypothesis, to inquire whether it can at all be reconciled with the phenomena of our solar system, with the origin and present condition of the planetary spheres? True, the only planetary system with which we are acquainted is our own, and even this can only be directly examined by us in its now completed state. But still, having supposed, according to an unquestionably legitimate mode of theorising, that, from some peculiarity in the nature and constitution of nebulous matter, nuclei are formed, there is, to a certainty, a pervading law of gravitation, by virtue of which the process of aggregation, or gathering towards the centre neighbouring matter, may take place, until not only masses are formed, but until masses greater or smaller are detached from the rest. By following out the consideration of the present hypothesis, and pursuing it to its consequences, we are brought to conclusions which so strikingly agree with the actual condition and arrangements of our system as it now presents itself, that we can scarcely but feel satisfied, if not of the entire accuracy of the nebular theory, at least of its near approach to it,—such an approach, indeed, as has not hitherto been afforded by any other hypothesis.

There is no law in nature better known as of fundamental importance, than that, when fluid matter tends towards or meets in a centre, it causes a rotatory motion, unless, indeed, the flow from all sides be so nicely balanced, that the opposite forces, or momenta, should neutralise each other, thereby producing a condition of *central rest*, the improbability of which occurrence, in regard to nebulous matter, being almost infinite. Instances of rotatory motion in nature may be happily furnished by mentioning the whirlwind and the whirlpool. Now, having supposed that there was a period when matter existed in no other shape or condition than that of a diffused self-luminous vapour, of the existence of which filmy substance we have at present ample manifestations; and supposing next, from the simple property of mutual attraction, which the particles of this matter possess, that its gradual concentration towards solid masses commenced, we are brought to the point, in the present hypothetical history, of having a rotatory motion established around a centre, which was most probably the first great phenomenon of our planetary system.

The instant a mass begins to revolve, centrifugal force has also begun; and, as the process of condensation goes on, the rotation becomes more rapid; and the result is a tendency to throw off the outer portions

of the mass. In fact, there are now two principles or forces acting in opposition to each other, the one attracting *to*, the other flinging *from*, the centre; the mass remaining in an entire state so long as the two powers continue exactly counterpoised. But the instant that the centrifugal force exceeds the attractive, outer portions,—a ring or belt,—will be thrown off; just as in the case of the grindstone, the outer portion of which is separated from the inner, when the mass acquires a certain velocity in its rotatory motion. Let the condensation still proceed, and at length another ring or belt of matter will be detached as before; so that a series of concentric rings may be formed around the central nucleus, each retaining the velocity possessed by that mass, at the moment of separation. These processes may have been repeated until the central mass, probably by its cooling, acquired the ultimate limits of the condensation imposed upon it by its constitution, the solidity produced by the hardening, it is to be presumed, of the outer crust, being at length such as to resist the attractive force.

Next, suppose that these rings are of a nature to partake of the tendency to consolidation; there is a probability that each would continue in its original shape or condition, that is to say, if each remained in a precisely equal thickness in every part of them—a very unlikely thing indeed. The almost incalcu-

lably greater probability is, that they would not remain so, from the irregularity in their constitution; and that instead of this result their tendency would be to consolidate towards centres of superior solidity, by which the spherical or annular form would be destroyed. What then? These still ductile and fluid rings would break into parts or pieces, forming separate masses, the largest of which would be likely to attract the lesser into itself. The entire mass would then settle into a spherical form, by that still all-prevailing law of gravitation. In a word, it would become a planet, revolving round the central and primary mass of nebulous matter, which we shall call a sun. The rotatory motion of this planet might continue, and satellites might next be flung off, in due course, from its mass, just in the manner that the first cast-off masses, or primaries, had been driven away, and thus a system of worlds might be produced.

Take now a survey of our own solar system, which is regarded as complete, although of comparatively recent formation, and it seems to us impossible to resist the conclusion that here has been a very close realisation of the results which have been above supposed; for, may it not be held as an exceedingly probable fact that the nebulous rings, which had primarily been flung off from the original mass, have

consolidated into spherical bodies, called planets; several of these bodies, in their turn, throwing off one or more rings, which have become secondary masses, called satellites, the whole having motions of their own? But are there not exceptions in our planetary system to the processes which are thus so confidently described? Yes, but such exceptions as seem to prove the general rule; for while there are many probabilities against the matter of the rings being sufficiently equable to remain and settle in the annular shape till they were consolidated, yet in some cases it might be otherwise, the equability prevailing. May this not have been part of the history of the two rings of Saturn, which seem to present a permanent and unmistakeable evidence of what was once the condition and state of progress of the planetary masses? Again, supposing a ring to break up, it is very probable that the fragments might separately shape themselves, and, of course, into globular forms; and this, it is conjectured, must have been the fate, at one period, of the ring between Mars and Jupiter, in place of which there is now found four or five planets, much under the size of the smallest of the rest, moving nearly at the same distance from the sun, yet in orbits of such different planes and so eccentric, that they keep apart. According to all this, the probability is, that the sun and all the planets, with their satellites,

of our system have had an origin in such nebulous matter as the telescope reveals to us. The same views serve to explain, in a manner that is satisfactory, the revolutions of the planets and their satellites in one direction, and in nearly circular orbits, with but little inclination to each other; all these conditions being required in order to secure and uphold the general stability of the system; as well as for the rotation of the sun and of the planets on their own axes. Besides and beyond all this, mathematical calculation has been brought to bear on the question, so as to account for the respective *times* of revolution which the planets ought to occupy, according to the theory, in going round the centre. Here, again, the result most strikingly favours the hypothesis; for it is found that there is a very close agreement between the space of time which each planet takes to revolve round the sun, and that in which the whole nebular mass is estimated,—from the known period of the sun's rotation upon his axis,—to have revolved at the time when the planetary ring was flung off, calculating the whole mass's dimensions to have extended at the period to the orbit of the particular planet.

Want of room forbids us to notice the speculations with regard to the probable results of the sun's connection with the Zodiacal Light, and the permanence of that nebulous matter in its present state and

relationship. The thing assuredly forms an interesting subject, were it but as bearing upon the nebular hypothesis, and the conjectures which that theory have originated—a theory, whatever may be its other qualities, which amazingly tends to exalt our conceptions of the stupendous nature and extent of the material universe; for it teaches us to look upon the most distant and filmiest patch which the telescope has brought within view, as an assemblage of worlds melted by remoteness into a thin vapour, yet composed of individual members as perfect, as vast, and as progressive in their constitutions as our own. "What mean, for instance," says Professor Nichol, "those dim spots, which, unknown before, loom in greater and greater numbers on the horizon of every new instrument, unless they are gleams it is obtaining, on its own frontier, of a mighty infinitude beyond, also studded with glories, and unfolding what is seen as a minute and subservient part! Yes, even the six-feet mirror, after its powers of distinct vision are exhausted, becomes in its turn simply as the child gazing on these mysterious lights with awful and hopeless wonder. I shrink below the conception that here—even at this threshold of the attainable—bursts forth on my mind! Look at a cloudy speck in Orion, visible, without aid, to the well-trained eye; *that* is a stellar universe of majesty

altogether transcendant, lying at the verge of what is known. Well, if any of these lights from afar, on which the six-feet mirror is now casting its longing eye, resemble in character that spot, the systems from which they come are situated so deep in space, that no ray from them could reach our earth until after travelling through the intervening abysses during centuries whose number stuns the imagination. There must be some regarding which that faint illumination informs us, not of their present existence, but only assuredly they were, and sent forth into the infinite the rays at present reaching us, at an epoch farther back into the past than this momentary lifetime of man, by at least *thirty millions* of years!"

The views unfolded and suggested by the nebular hypothesis lead to the very highest generalisations, such, indeed, as are far more comprehensive than any principle or law in nature with which we are yet well acquainted,—conducting us even to the fundamental properties of matter, the actions of which produce the phenomena termed electrical and chemical, as also those relating to light and heat. The farther we proceed the more forcibly must we be struck by the simplicity and uniformity of the laws by which the most stupendous effects are produced. How worthy of admiring observation are

those physical laws, which we behold working on every scale, the smallest and the greatest, with the same regularity. Whatever may be thought of the hypothesis which has been under our consideration, it has, at any rate, this merit,—although not, perhaps, furnishing the true or exact key to the mystery of the origin and destiny of things,—that of discovering in the vast heavens, as well as among the phenomena around us, that all things are in a state of change and *Progress;* "that there too, on the sky," again to cite Dr. Nichol,—"in splendid hieroglyphics, the truth is inscribed, that the grandest forms of present being are only *Germs*, swelling and bursting with a life to come! And if the universal fabric is thus fixed and constituted, can we imagine that aught which it contains is unupheld by the same preserving law, that annihilation is a possibility real or virtual—the stoppage of the career of any advancing Being, while hospitable Infinitude remains? No! let the night fall; it prepares a dawn, when Man's weariness will have ceased, and his soul be refreshed and restored. To Come!—To every Creature these are words of Hope spoken in organ tone; our heart suggests them, and the stars repeat them, and through the Infinite, aspiration wings its way, rejoicingly as an eagle following the sun."

THE PROSPECTS OF ASTRONOMY.

NEVER did Astronomy make such advancing strides at any era, as the science has done of late years; while the enormous masses of observations which are now regularly published, are silently affording the means of increased accuracy in every department, being rapidly seized and applied for the advancement of the study. When one thinks of the vast field opened by the Nebular hypothesis, for example, again to quote Professor Nichol,—"of the little hitherto accomplished, compared with what remains to be done,—of the deep mystery still hanging over almost all of the vast skies,—there is apt to supervene a despondency, a hopelessness that the handwriting which is on them will ever be interpreted. But we take encouragement

from the aspects of the times. Astronomy is not now in that stage of its history in which only a few men in a century would consent to wear out a long and healthful age in examining the heavens. Observers of the first capacity and becoming ardour are yearly multiplying; while adequate instruments, through the advance of Art, grow more accessible. Doubtless, with all advantages, we, of this time, may do little more than roughly chart the boundary lines, and it may be, fix down the prominent points of the landscape;—the filling up and mapping of the details constitute the harvest of the future. But how soon may that future come! The wheels of time are revolving rapidly—truth mingling with truth, as light gathered into a focus. Alike within and around us, events succeed without the usual interval, nor is Astronomy unaffected by the general acceleration. The knowledge of what the Heavens are foreboding may not be long deferred; if we, in present times, industriously act our part, much, still unintelligible, will become plain to the generation whose buds at this moment are the spring tidings of the world,—the generation now pressing on us, and to which we must yield the stage."

But even when the highest knowledge of the works and ways of the Almighty has been reached that is attainable by man in this fleeting state, how limited

must his view be compared with what will be vouchsafed to the Blessed in an immortal life!—how much will remain to be revealed in that glorious future, when the light of Truth shall burst upon the beatified spirit in unclouded lustre, when the realisation will far transcend all our loftiest and most brilliant imaginings, being such as "eye hath not seen, nor ear heard, nor hath it entered into the heart of man to conceive." It is long since the Psalmist testified that "the heavens declare the glory of God, and the firmament showeth his handy work." How vastly more will these heavens reveal, when, instead of the span of life of "three-score years and ten," *Eternity* shall expand itself to the soul's contemplation, and instead of the regions within the ken of the telescope, the infinitude of space and of the Creator's Universe of glorious workings and beneficent riches shall be ever enlarging to the ecstatic redeemed ones who surround His throne!

"Open your lips, ye wonderful and fair!
Speak, speak! the mysteries of those living worlds
Unfold! No language! Everlasting light,
And everlasting silence? Yet the eye
May read and understand. The hand of God
Has written legibly what man may know,
The glory of the Maker. There it shines
Ineffable, unchangeable; and Man,
Bound to the surface of this pigmy globe,
May know and ask no more. In other days,

When death shall give the encumbered spirit wings,
Its range shall be extended ; it shall roam,
Perchance, among those vast mysterious spheres,
Shall pass from orb to orb, and dwell in each,
Familiar with its children, learn their laws,
And share their state, and study and adore
The infinite varieties of bliss
And beauty, by the hand Divine,
Lavished on all his works. Eternity
Shall thus roll on with ever fresh delight;
No pause of pleasure or improvement ; world
On world still opening to the instructed mind
An unexhausted universe, and time
But adding to its glories. While the soul,
Advancing ever to the source of light,
And all perfection, lives, adores, and reigns
In cloudless knowledge, purity, and bliss."

THE END.

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