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1833.

The Solar System.

A

TREATISE

ON

ASTRONOMY;

WITH A

MAP OF THE SOLAR SYSTEM.

GIVING

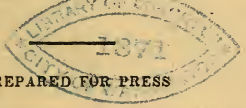
A CORRECT DESCRIPTION

OF THE

HEAVENLY BODIES,

AND

Embracing the First and most Important Principles of Astronomy.



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PREFACE.

MANY valuable treatise on Astronomy have been published, and laudable efforts made to disseminate the knowledge of this important subject. But a great proportion of the community still remain uninformed. They annually purchase an Almanack, and receive some assistance from it; but much of it is unintelligible to them, and of course uninteresting and useless. Being in a measure precluded from the means of instruction, they imagine themselves to be incapable of understanding this science, and take it for granted that they are inevitably doomed to remain in the dark. This impression leads them to treat the subject with indif-

ference. Their indifference would be less lamentable, were it not attended with erroneous views, and superstitious notions, which tend to weaken and contract the mind.

This evil cannot be removed at once; but it may be gradually prevented. It is not necessary for this purpose, that a person should become extensively acquainted with Astronomy; but it is necessary that they should understand the *first principles* of this science. Newton, Herschel, and other eminent Astronomers have so prepared the way, that any person of ordinary abilities, may soon acquire this knowledge. He cannot demonstrate the laws by which the Heavenly bodies move, without the knowledge of mathematics; but he can find the planets and constellations, and know what discoveries others have made. He can so extend his views, as to be able to see,

and explain the reason of those occurrences, which by many, are deemed unaccountable and ominous. He can do so without extensive reading and study, and without relinquishing his ordinary employments. But he cannot do it without thinking. His mind must be active—his attention fixed, and suitably directed.

Astronomy is eminently calculated to call into vigorous exercise, the noblest powers of the mind, so as to exclude low and debasing thoughts. It is suited to excite, and gratify the curiosity of the young—to turn away their eyes from beholding vanity—to extinguish their unhallowed desires, and thus to prevent them from disturbing others, and destroying themselves.

And again, Astronomy is of practical utility to man, and exerts an influence on his wants and his enjoyments; for all, without the aid of this

science, would be ignorant even of their own age, for without it, we should have no chronology, and no calendar.

By a careful perusal of this work, a person will acquire a lively interest in the science of Astronomy, and persue the study with delight, which is so peculiarly adapted to enlarge and elevate the mind of man.

This treatise embraces all the first principles of Astronomy; and so arranged, that all may understand it; and so short, that none may be discouraged from reading it.

INTRODUCTION.

It is not the design of the Bible to explain the laws of nature; but to teach us what we must do to be saved. It frequently alludes to the natural Heavens, and speaks of them according to their appearance, and leaves us to extend our acquaintance with them by such means as providence affords us.

Whether the history of creation, which the Bible gives, relates to the fixed stars, or only to the Solar System, is not certain. But it is certain, that He who made all things is God. And it is His work that now claims

your attention. The same Moon and Stars that excited devotion in the Psalmist, still declare and glorify God, and the firmament showeth his handy work.

While we contemplate his power, wisdom and goodness, as they are manifested through the visible creation, let us fear and adore his great name and commit the keeping of our souls to him in well doing, as to a faithful Creator.

CHAPTER I.

THE EARTH.

THE Earth is suspended in empty space, with nothing to support it, but the power of God. It is found to be a great globe or ball; for

1. The shadow of it appears round on the Moon, when eclipsed.

2. Many persons have sailed round it.

3. The highest part of a ship at sea is seen first.

4. As you travel north the Sun and stars move toward the south, and as you travel south they move toward the north. This must be owing to the convexity of the earth; for a million of miles, on a horizontal plane, would occasion no variation in the appearance of the fixed stars; and but very little in that of the Sun.

5. The north pole becomes elevated as you travel north, which would not be the case if the Earth were not round.

Mountains and vallies are so small in comparison with the Earth, that they do not materially affect its shape.

The earth is a little flattened at its north and south ends. It ought to extend seventeen miles farther each way, to be entirely round.

Should you continue to travel in any direction you would come round the Earth to this place again, and see the heavens over your head all the way. Toward them is *upward*, and toward the Earth is *downward* in every place. For God has established a law, called the *attraction of gravitation*, by which every thing on and near the Earth, is drawn toward its centre. This is the reason that material substances have weight. They are light or heavy according to the force by which they are attracted. If you throw a stone into the air, it will return because it is drawn

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N. B. For the explanation of terms relating to Astronomy look to the Glossary at the end of this book.

back. This mysterious law, which operates uniformly in every place and on every particle of matter, is calculated to remind us of the immediate presence, power and goodness of God.

CHAPTER II.

THE DAILY REVOLUTION OF THE EARTH.

By the general law relative to the material universe, the Earth is caused to roll round toward the east once in twenty-four hours. You do not perceive that it moves, because you partake of its motion. Were you to sail ever so rapidly on smooth water, you would not be conscious of moving. You might walk across the boat, and step into another boat that had the same motion; or throw articles into it, or into the air, and all would seem as if you were at rest. But objects really at rest would appear to move in a direction contrary to that in which you were sailing. There are

no objects around us, but that has the same motion with the Earth, except the Sun, Moon and stars. These seem to move toward the west. It is absurd to suppose they really do thus move. For such is their distance, that the Sun must move more than six thousand miles, and the fixed stars many millions of miles every second, in order to perform a revolution round the Earth in twenty-four hours; and they must do this without any known law, and even contrary to the known laws of nature.

Twilight is the reflection and the refraction of the Sun's rays from the upper part of the atmosphere.

CHAPTER III.

THE REVOLUTION OF THE EARTH ROUND THE SUN.

The Sun is a great globe more than a million times larger than the Earth. Its light and heat are probably occasioned by

the combustion of gas in its atmosphere. It performs a rotation on its axis once in twenty-five days, as appears from the dark spots on its surface; and it is carried round in a small space, because it is attracted by the planets. But it always remains in that part of the Heavens, where God at first placed it. Since material bodies attract one another in proportion to their respective nearness and quantities of matter, the Earth attracts the Sun and the Sun much more powerfully attracts the Earth. Hence they would be drawn together, were not the Earth whirled round the Sun in a circle, which is called its orbit.

Thus the Earth has two motions, like a wheel, rolling round while it moves along. The imaginary line on which it rolls, is its axis and the ends of the axis its poles. Its rovolution on its axis causes day and night; and its revolution in its orbit causes the seasons of the year. Its orbit is not a perfect circle; for it is three millions of miles nearer the Sun in the winter, than it is in the summer.

To illustrate the law by which the Earth moves in its orbit, hold a ball by a string,

and let it receive a stroke which would tend to throw it forward. Instead of taking that course it will revolve round your hand in a circle. If you jerk the string every time it comes round so as to preserve the motion it first received, it will continue to revolve. Your hand represents the Sun, and the ball the Earth. The stroke which the ball received represents the force called the *projectile force*, which God gave the Earth at creation. The tendency which the ball has to fly off in every direction, as it whirls round, is the *centrifugal force*. The string, which prevents it, represents the *centripetal force*, or the Sun's attraction, which holds the Earth during its yearly revolution.

This ball would continue to revolve as the Earth does, without any motion of your hand, were it not retarded by the Earth's attraction. For it is a law of nature that a body at rest will never move, unless something moves it; and that when once moved it will never stop, unless something stops it.

The Earth goes round the Sun in three hundred and sixty-five days and about six

hours. These odd hours make a day in four years, which is added to February. When this is done the year is three hundred and sixty-six days long, and is called leap year.

CHAPTER IV.

THE SEASONS OF THE YEAR.

Twice in a year, the 20th of March and the 22d of September, the Sun crosses the equinoctial line, (the equator.) Then the day and night are equal—each twelve hours long, all over the world, except at the poles, where the Sun is seen by the refraction of its rays when it is below the horizon. But on the 21st of March the Sun sets at the south end of the Earth, and does not rise there again for six months; and at the same time it rises at the north end, and does not set there again for six months. The reverse takes place on the 23d of September. Our seasons, and the relative length of our days and

nights are directly opposite to those on the other side of the equinoctial line or southern half of the Earth. When we have summer with long days, it is winter with long nights there.

Summer and winter are caused by the Earth's axis inclining toward its orbit, and the north pole to point always toward one particular part of the heavens, during the yearly revolution. Near the part toward which it points there is a star called the Polar Star. Neither the Earth nor the Sun is, in reality, any farther to the north or south at one time than at another.

Let a candle represent the Sun, and a ball the Earth. Run a small rod through the middle of the ball for its axis. Direct the north end toward the Polar Star. Holding it in this position carry it round the candle in a perpendicular circle, and you will see that the light shines half the time on the north end of it, and half the time on the south end; and that at two points in the circle it shines at she same instant at both ends.

Roll the ball round to the east three hundred and sixty-six times, while carry-

gether, viz. about the 14th of April, 16th of June, 31st of August and 24th of December. On all other days the Sun is either faster or slower than the clock. This difference is called *the equation of time.* The Sun does not vary from twenty-four hours a half of a minute any single day; but by an accumulation of difference it is sometimes as much as sixteen minutes faster or slower than the clock, which uniformly marks the time.

The Earth has its slowest motion in the summer; because it is then at its greatest distance from the Sun. Hence it is eight days longer on this side of the equator, than on the other.

CHAPTER V.

THE MOON.

The Moon is a round body like the Earth, but forty-nine times less. It receives all its light from the Sun. That part of it which is turned toward us is enlightened as far as it is turned toward the Sun. There

are however darkish spots on its disk even when it is enlightened. These are occasioned by mountains and valleys, which intercept the Sun's rays. Several of them are volcanoes.*

The substance of the Moon is more known to us than that of the Sun. There is ground for supposing that all is solid at its surface, for it appears, in powerful telescopes, as an arid mass, on which some thought they could perceive the effects and even the explosions of volcanoes. There are mountains on the surface of the Moon which rise nearly to the height of three miles, and it has been inferred that it has deep cavities, like the basins of our seas. Caspian lakes have been supposed in it. But it either has no atmosphere or it is of such extreme rarity, as to exceed the nearest vacuum we can produce by our best constructed air pumps; so that no terrestrial animal could breathe on its surface. If then it be inhabited, it is not by beings who have bodies like either

* If you understand Geometry, and wish to find the height of a lunar mountain, first ascertain the distance and diameter of the Moon: and when it is half illuminated observe on its unenlightened part the bright spots, as

men, or any of our animated race. The lunar population must be of a far more ariel nature than our present selves, or our most delicate fellow creatures. It has a great number of invariable spots that prove that the Moon always presents to us the same hemisphere, and revolves on its axis in a period equal to that of its revolution round the earth. Its dark and bright parts have given rise to the idea, that it has seas, islands, and continents, but it is doubted whether it has any water at all; and it has been supposed, that if it had any ocean, the superior attractions of the Earth, especially in conjunction with the Sun, would draw the aqueous fluid into a deluge over a large part of its surface. The light of the Moon is three hundred thousand times more feeble than that of the Sun. From this inferiori-

they first appear. These are produced by the rays passing over the intermediate convex surface, and striking the tops of the mountains. Find the length of the line from one of these spots to the line of illumination by the angle it subtends; and from each end of it, draw a line to the Moon's centre; and you will have another right ang' d triangle, two sides of which and the included angle are known. Hence the other side from the bright spot to the centre of the Moon is easily found. From this substract the Moon's radius, and the remainder is the height of the mountain.

ty, the lunar rays, when collected in the most powerful mirrors, produce no sensible effect on the thermometer. Indeed, they appear to have a cold producing agency, according to the experience of practical men, though philosophers have not yet ascertained the fact by direct experiments. That they have a peculiar and salutary influence on the animal frame, appears to have been actually experienced. Its peculiar effects have been so often observed in mental derangement, that this malady has been named lunacy from them.

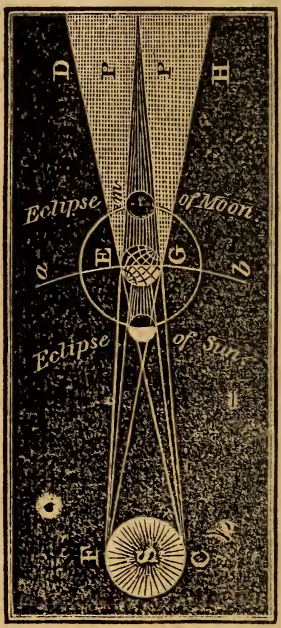
The Moon is two hundred and fifty thousand miles from the Earth, and about two thousand miles in diameter. It goes round the Earth every month, and moves with less rapidity in the winter than in the summer. For the Sun, being nearer to it retards its motion. The orbit in which it moves round the Earth is not a circle, but an *ellipse*. That point of it, which is nearest to the Earth, is called perigee; and that point, which is farthest, is apogee. The Moon is therefore once in perigee, and once in apogee every month. Its monthly course never

varies more than 5½ degrees from the Sun's annual course. When full it is in nearly the same direction the Sun was six months before. Half of the time it is on the north side of the Earth's orbit; and half the time on the south side. Hence it crosses the plane of the Earth's orbit twice a month, or once in about fourteen days. The points, where it crosses, are called its nodes. The point, where it crosses from south to north, is its ascending node; and where it crosses from north to south its descending node. These points move backward or toward the west 1° 38′ a month. That is, the Moon continues to cross farther and farther to the west, so as to perform a great revolution in about nineteen years; when it will again cross where it now does. It is necessary to observe this circumstance in order to calculate

ECLIPSES.

The Moon eclipses the Sun, when it comes between us and the Sun; and it is eclipsed when it passes through the Earth's shadow.

AN ECLIPSE.



The above print is a correct representation of an Eclipse.

S represents the Sun, *m* the Moon, E G the Earth, P the Earth's Penumbra, *a b* a part of the Earth's Orbit. The straight lines are the Sun's rays.

When it changes or is at the full, it is usually too far to the north or south to occasion an Eclipse. But when it changes it will eclipse the Sun, if it is within 16 degrees of a node; and when at the full it will be eclipsed, if it is within 12 degrees of a node. If it is at such times exactly in one of its nodes, the eclipse will be total, or central. When it is in or near its apogee at the time it centrally eclipses the Sun it produces what is called an annular eclipse. That is, a ring of the Sun will be seen around it. For it is so far off that its disk will appear less than that of the Sun. There can never be more than seven, nor less than two eclipses in a year. The usual number is four.

To illustrate the immediate cause of eclipses suspend a ball to the Sun, and then move your hand round it so as to represent the revolution of the Moon round the Earth. When your hand passes directly between the ball and Sun, the shadow will fall on the ball, and with respect to it the Sun will be eclipsed. When your hand passes to the opposite side it will receive the shadow of the ball, and be eclipsed as the Moon is when the Earth is directly between it and the Sun.

If the Moon be in or near its apogee, some of the rays of the Sun will cross one another between her and the Earth, and then the eclipse of the Sun will be annular.

Astronomers have furnished tables by which any one may learn to calculate eclipses. But it is not expedient for persons in ordinary circumstances to attempt it. For the advantage they would derive from it, would by no means compensate them for the time and study, that are necessary to render the process familiar.

CHAPTER VI.

THE INFLUENCE OF THE MOON.

THE HARVEST MOON.

The Moon affords us much more light in the *early* evenings of autumn, than in those of any other season. For then, about the time of its full, it varies only about two hours in the time of its rising for six days together. It is then called

the *Harvest Moon*, because it aids men in gathering their harvest. This circumstance attends the rising of the Moon every month, when it is in or near Aries; but it does not rise there when full, except in autumn. When there is the least difference in the time of its rising there is the greatest difference in the time of its setting; and the reverse.

In the long nights of winter the moon continues much longer above the horizon, near its full, than at other times; because it then passes near where the sun was in the summer.

The goodness of God is thus very conspicuous, in that he furnishes us with the greatest portion of moonlight, when we need it the most.

TIDES.

As the Moon is only about two hundred and fifty thousand miles from us, it attracts the earth with considerable force. Hence it renders all material substances immediately under it lighter than they otherwise would be: for it counteracts the tendency which they have towards the

Earth's centre. But it produces no sensible effect on solid substances; nor on small collections of water, which have all their parts equally attracted by it at the same time. But on the wide ocean the effect is very perceptible. For there the waters directly under the Moon, having their weight diminished by it, are pressed upward by the surrounding heavier waters; just as a piece of wood is, if it be lighter than an equal bulk of the water in which it is immersed. Being thus elevated they roll on till they meet the shore, where they accumulate.

But the Moon's attraction unites with that of the Earth on the opposite side, so as to *increase* the weight of the waters there. Those that are directly opposite to the Moon, being farthest from it, are least attracted by it. Hence they likewise are forced upward by the surrounding heavier waters.* Thus the Moon

* The reason generally assigned for the tide opposite to the Moon is, that the centre of the Earth, being more attracted than the opposite waters, is in a measure drawn from them, Or that these opposite waters rise on account of the centrifugal force they acquire by the revolution of the Earth round a common centre with the Moon. But it seems indisputable, that the effect is partly, at least, produced by the cause stated above.

produces two tides at once, which follow it round the Earth. When it is above us we have a tide, and when it is below us we have a tide. They recur once in about twelve and an half hours. For as the Moon continually moves toward the east, it is about twenty-five hours in passing from the meridian to the same meridian again.

In the same way the Sun produces two tides every day. But it is so far off that its tides are very small. When the Moon changes, or is at its full, its tides unite with those of the Sun, and become *spring tides.* At other times the Sun's tides diminish those of the Moon, and produce *neap tides*, when directly contrary to them; as at the first and last quarters of the Moon. For then the Sun tends to produce low water, where the Moon tends to raise it.

There are several causes, which separately tend to raise the tides higher than usual. When two or more of these unite, the tides are proportionably increased. Thus if the Moon be in perigee, when full or new, the tides will be higher than at other times. For it then, being nearer to

the Earth, attracts the waters with greater force. The spring tides are the greatest of all about the middle of March and the latter part of September. For then the Sun and Moon, being both near the equator, unitedly exert a more direct influence in raising the waters; and the influence of the Sun on the waters is greatest, when it is on the south side of the equator; for it is the nearer to the Earth than it is when on the north side.

THE MOON'S INFLUENCE ON THE WEATHER.

The same causes, which raise tides in the ocean, raise much higher and corresponding tides in the atmosphere. These have a great effect on the weather. The effect would be uniform, so as to produce periodically the same kind of weather, were not the atmosphere subject to changes arising from other causes. God has designedly left us in a state of uncertainty respecting this subject, that we may more sensibly feel our dependence on him. He causes it to rain on one city, and causes it not to rain on another city; by the operation of laws which are hidden from us.

But he affords us opportunity of forming probable conjectures concerning the future state of the weather. From the law, by which the tides rise and fall in the atmosphere, many valuable calculations of this kind may be made. For the weather usually changes at *spring and neap* tides. It either storms, is cloudy, or cold at that time. An equinoctial storm may always be expected, when the Moon is full or new, near the time of the equinoxes; especially if it be at the same time in perigee. In some seasons the weather is foul at the change, full, and quarters of the Moon; and fair during the interims. The weather has other changes, which periodically return with the Moon. By observing these periodical changes we may calculate what the weather will probably be for many future weeks. But still *clouds without rain* will often disappoint our expectations, and storms will sometimes come without waiting for the Moon.

It is a common remark, that a thunder shower will not come up against the Moon; that it will be either scattered, or carried to the northeast, and arrive from that direction. If this be a fact it is doubtless

occasioned by the commotion, which the tide produces in the upper regions. When the Moon runs high it will probably bring a cold breeze from the north.

The Moon affects the sap of vegetables, and perhaps some regard may properly be had to it in gathering the fruits of the earth; but no reason appears, why any regard should be had to it in sowing seed.

THE MOON'S PLACE.

The notion, that the Moon affects different parts of the body according to its place in the Heavens, seems to have originated from a harmless contrivance of the ancient astronomers. They divided that part of the Heavens, through which the Moon passes round the Earth, into twelve equal parts called signs. They were then led to adopt a device, by which they might readily express and remember the relative situation of these signs. For this purpose they considered the human body as divided into twelve parts; each part answering to a particular sign, the head answering to the first sign, where they imagined that they saw, in the location of the stars, some resemblance of a ram's head. Hav-

ing thus begun, they could easily complete the device, so as to imagine that every sign contained some resemblance to a corresponding part of the body. Then it would be natural, and convenient in describing the Moon's place to say, that it was in the head, neck, and arms, &c.

This simple contrivance, in the dark ages of the world, prepared the way for a delusion, which has been perpetuated to the present day. Those who publish Almanacks, encourage it for the sake of rendering their work saleable. Hence they insert a column for the Moon's place, as if it governed successively different parts of the body. But let any person become acquainted with the principles of astronomy, and he will detect this imposition, and look for the Moon's place in the Heaven's instead of the head, neck, and arms. He will see that, when according to modern Almanacks, the Moon governs the head, it is actually in that part of the Heavens, where the ancients supposed it governed the feet,* and that it will not again have the same relative position there, under nineteen years.†

* See Chapter X. Precession of the equinoxes.

† See Glossary. Cycle of the Moon.

As the Moon's nodes perform a revolution in nineteen years, the Harvest Moon continually varies. The difference in the time of its rising is greatest when the *descending* node is in Aries, where it was in 1830; and the difference is least, and of course the Harvest Moon is most beneficial, when the *ascending* node is in Aries, where it will be in 1839. The Moon in its monthly course runs high, when in Cancer, and low, when in Capricorn. It runs unusually high and low, when its *ascending* node is in Aries; for then its greatest latitude is north of the summer Solstice, and south of the winter Solstice. But nine years afterwards, when its *descending* node comes to Aries, it does not run so high and low by more than ten degrees. Thus it continually varies toward the north or south with respect to the same signs. The Moon is said to go round the Earth every month; but in reality they both revolve round a common centre. To illustrate this, run one end of a stick into a large apple, and the other into a small one; and then make it turn round on a pin, run through it at the point, where they exactly balance each other.

CHAPTER VII.

THE SOLAR SYSTEM.

The Solar System includes the Sun, seven Primary Planets, four Asteroids, eighteen Secondary Planets or Moons, and more than a hundred Comets. The names of the Primary Planets are Mercury, Venus, the Earth, Mars, Jupiter, Saturn and Herschel. The names of the Asteroids are Ceres, Pallas Juno and Vesta. The Earth has one Moon, Jupiter four, Saturn seven, and Herschel six.

The Sun is in the centre of the system, and these other bodies revolve round it as they are represented in the map.

Mercury, being the nearest to the Sun, moves round it in a small circle.

Venus revolves in a larger circle, but within the Earth's orbit.

Mars goes round the Earth's orbit.

Next come at different distances, the *Asteroids*, Ceres, Pallas, Juno and Vesta.

Then *Jupiter*, in a still larger orbit, with four Moons revolving round it.

Beyond this is the orbit of *Saturn* with its seven Moons.

Herschel at a vast distance, with its six Moons, rolls slowly round the orbits of all the other planets.

Occasionally a Comet darts through these orbits, and seems to threaten destruction to the whole system. But directed by the hand of the Almighty, it flies round the Sun; and harmlessly retires again, for ages, into the unknown regions of space.

All the planets revolve by the same law the Earth does; and most, if not all of them rotate, so as to have day and night, as well as different seasons.

The irregularity of the Comets arises from the fact that their *projective* force was at first disproportioned to their *centripetal* force. It was either too great, or too small, for the purpose of making them revolve in circles. Hence their *centrifugal* force, which is only a modification of the *projectile* force is continually varying.

You may form an idea of the law that governs the Comet by slinging a stone, which being brought rapidly round your hand, passes off with great velocity. Or by giving a sudden jerk to the string, while whirling a ball, and then letting go.

If while the ball flies off, your hand attracted it, as the Sun does a Comet, it would be gradually retarded, and at length brought back in a curved line, and violently thrown off again in its former course.

The irregularity of the Comets is probably conducive to the order of the Solar System, which is exactly balanced by him who formed the worlds.

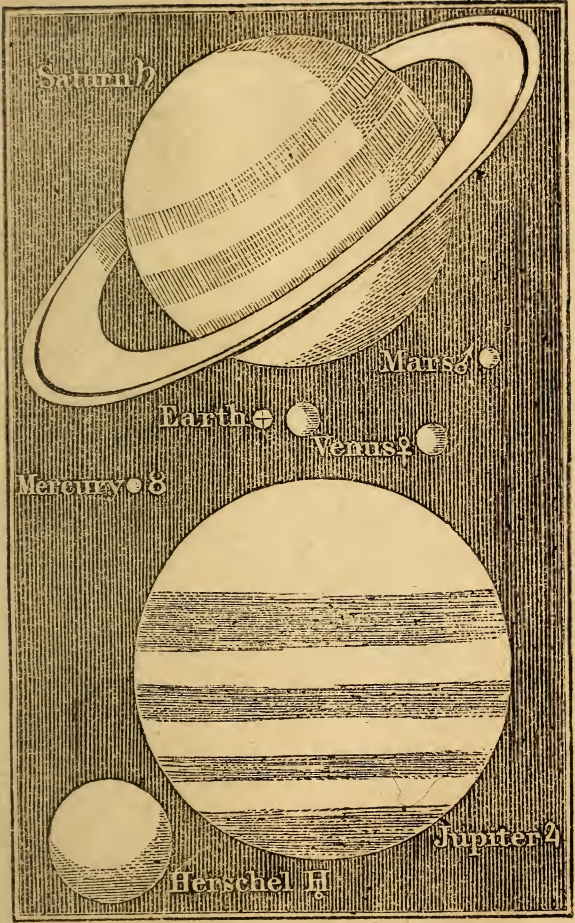
CHAPTER VIII.

MAGNITUDES AND DISTANCES OF THE PLANETS.

By gradual discoveries astronomers have at length ascertained the diameters of the planets, their distances from the Sun, the times in which they perform their revolutions, and their hourly motions in their orbits. These may be seen at one view in the following table, expressed in round numbers. You will observe that in this table the *mean* distance of every planet is given, or that which is between its greatest and the least distance from the Sun.

TABLE.

Names of the Planets.	The Diameter in miles	Distance from Sun in millions of miles.	Length of the day, or rotation on its axis.	Year, or yearly revolution.	Hourly motion in its orbit, in miles.
Mercury,	3,200	37	Unknown	3 mo's.	111,000
Venus,	7,600	68	23h. 20m.	7 mo's.	81,000
Earth,	7,900	95	24h.	12 mo's.	68,000
Mars,	4,200	144	24h. 39m.	23 mo's.	56,000
Ceres,	161	266		4 y'rs.	
Pallas,	80	266		4 y'rs.	
Juno,	100	255		5 y'rs.	
Vesta,	238	217		4 y'rs.	
Jupiter,	89,000	492	9h. 55m.	12 y'rs.	30,000
Saturn,	79,000	902	10h. 16m.	29½ „	22,000
Herschel,	35,000	1,800	Unknown	83½ „	15,000



The above print represents the planets in their true proportions.
Note—The elipses round Saturn, represents his rings.

By this table and figure, it appears that Mercury is much smaller than the Earth, and much nearer to the Sun. It is seldom seen, and never far from the Sun. Venus is nearer to the Sun than the Earth is. Hence it is always either a morning or an evening star. It appears larger than any other star; but it is not quite as large as the Earth. Mars is still smaller: it has a red fiery appearance; but its apparent magnitude is continually varying. When on this side of its orbit it is large and bright; but at other times small and dim. The telescope shows that it has snow on its north and south ends, which melts when its summer approaches. The Asteroids are comparatively very small. They can hardly be distinguished by the naked eye. Jupiter is one thousand four hundred times larger than the Earth. It appears almost as large and bright as Venus. Its four Moons cannot be seen without a telescope. By the eclipses of Jupiter's Moons it is ascertained that light is sixteen and a half minutes in crossing the Earth's orbit, and eight and a quarter minutes in coming to us from the Sun. Saturn is one thousand times larger than the

Earth. It appears bright and redish, but not as large as Jupiter. It is surrounded by two broad flat rings, lying in the same plane. The nearest is thirty-four thousand miles from the planet, and twenty thousand miles wide. The other is two thousand miles beyond the first, and seven thousand miles wide. But neither these nor its seven Moon's can be seen by the naked eye. Herschel is ninety times larger than the Earth. It can scarcely be seen, except by the telescope. It received its name from Dr. Herschel, who first discovered it. All the planets receive their light from the Sun, and shine by reflection.

These huge bodies, which differ from one another so widely, with respect to their magnitudes, distances and motion, roll on in perfect harmony according to the laws, which their Creator first assigned to them. It appears from observation and experiments, that the laws of motion are general and uniform.

If a suitable number of balls were so made, placed, and propelled, as to bear the same relation to one another, in these respects, that those of the Solar System

do ; they would, of their own accord, for ever revolve in the same order ; were they not prevented by the Earth's attraction, or some other extraneous impediment.

CHAPTER IX.

THE CONCAVE OF HEAVEN.

The Heavens appear like a great canopy spread over us ; or rather like a hollow globe, in the midst of which we are placed, viewing successively the concave surface, while we are rolled round by the daily revolution of the Earth.

In order to become acquainted with the Heavens, we must consider them as divided into different regions. The grand divisions of them, that are usually made, correspond with those of the Earth.

The *Equator* is an imaginary circle passing round the Earth, dividing it into northern and southern hemispheres.

The ecliptic marks the place, over which the Sun seems to pass during the successive seasons of the year. It is the plane of the Earth's orbit. This and the plane of the equator are indefinitely ex-

tended; so that the equator and ecliptic of the Earth, coincide with the equator and ecliptic of the Heavens: and the axis and poles of the Earth are so extended, as to become the axis and poles of the Heavens. The sensible horizon is the circle, where the Heavens and Earth seem to meet.

Every circle is divided into three hundred and sixty equal parts, called degrees; every degree contains sixty minutes; every minute sixty seconds.

Latitude is the distance north or south from the equator. But the latitude of a Heavenly body is reckoned from the *ecliptic.*

Longitude is the distance east or west from any point. But the longitude of a Heavenly body is the distance *east* from the point, where the ecliptic cuts the equator at aries.

CHAPTER. X.

THE CONSTELLATIONS.

The fixed stars do not change their relative situation like the planets, but remain perpetually fixed in the same parts

of the Heavens. Those of them that appear in clusters, are called constellations; to which the ancients gave such names as were supposed to be descriptive of the spaces they occupy. All the bright stars and nearly all that are visible, are now included in the constellations which are named in this Chapter.

Twelve of these constellations lie on the Ecliptic. Each one of them extends through a twelfth part of it, or thirty degrees. That portion of the Heavens which includes them is called the zodiack. The zodiack likewise includes the orbit of the Moon and of all the planets. It is about sixteen degrees wide, or eight degrees on each side of the ecliptic.

Mazzaroth is supposed to be the *twelve signs.* Pleiades, or the seven stars, are figuratively represented as maturing the fruits of the Earth. This constellation appeared in the summer evenings, when the book of Job was written. But on account of the precession of the equinoxes, it does not appear so early by nearly two months.

The Sun formerly crossed the equator in the spring of the year near the ram,

which was reckoned as the first of these twelve constellations; but the Sun now crosses the equator more than thirty degrees west of this. It will continue to cross farther west fifty seconds of a degree every year. This alteration is called the *Precession* of the *Equinoxes*. This period is completed in twenty-five thousand nine hundred and twenty years. Hence if the world continue twenty-three thousand seven hundred and sixty years longer, the Sun will again cross the equator south of the ram, where it did two thousand one hundred and sixty years ago. The precession of the equinoxes is caused by the accumulation of matter around the equator, which the sun attracts, when north or south of it, so as to bring the equator under it twenty and one fourth minutes sooner than it otherwise would.

The Sun apparently passes through all the constellations of the zodiack every year. The *daily* revolution makes it seem to go round the heavens once in twenty-four hours. This however does not alter its position with respect to the stars; for they seem to move round with it. But the *yearly* revolution of the Earth makes the Sun seem to move slowly toward the east.

Or what is the same thing, it makes the fixed stars seem to move slowly toward the west to meet the Sun ; so that they rise nearly four minutes earlier every night than they did the preceding night; till they rise before sun down, at noon, in the morning, and pass by the Sun, rise before it; and perform the same revolution over again.

Thus Arcturus and Orion make their appearance, move on towards the west, and are again lost in day light.

Walk round a candle or some distant object; and you will perceive that the direction in which you view it, as it respects other objects at rest, is continually changing. Thus as you are carried round the Sun once a year, the direction in which you view it continually varies, with respect to the fixed stars.

A catalogue of the Constellations arranged in classes. I. Those of the Zodiack. II. Those between the Zodiack and Lat. 48°. N. III. Those that never set as far north as Lat. 42°. IV. Those that are south of the Zodiack. V. Those that never rise as far north as Lat. 42°.

I.

The Ram.
The Bull.
The Twins.
The Crab.
The Lion.
The Virgin.
The Scales.
The Scorpion.
The Archer.
The Goat.
The Water Bearer.
The Fishes.

II.

The Flying Horse.
Andromeda.
Perseus.
Medusa's Head.
The Waggoner.
The Lynx.
The Little Lion.
Berenice's Hair.
Bootes.
The Grey Hound.
The Harp.
The Swan.
The Lizard.
The Eagle.
Antinous.
The Dolphin.
The Arrow.
The Fox and Goose.
The Horse's Head.
The Northern Crown.
The Serpent.
The Serpent Bearer.
Hercules.
The Bull of Poniatowski.
Sobieski's Shield.

III.

The Little Bear.
The Great Bear.
The Cameleopard.
The Dragon.
Cassiopeia's Chair.
Cepheus.

IV.

The Whale.
The River Æridanus.
The Phenix.

Orion. *The Sculptor's Shop.*
The Hare. *The Crane.*
Noah's Dove.
The Great Dog. *V.*
The Little Dog.
The Unicorn. *The Altar.*
The Ship Argo. *The Indian.*
The Hydra. *The Peacock.*
The Sextant. *The Bird of Paradise.*
The Mariner's Compass. *The Camelion.*
The Air Pump. *The Southren Triangle.*
The Crow. *The Flying Fish.*
The Centaur. *The Sword Fish.*
The Wolf. *The American Goose.*
The Southern Crown. *The Water Snake.*
The Southern Fish. *The Telescope.*
The Microscope.

A few obscure constellations are omitted in this catalogue. The whole number is eighty. Only forty-eight however were named by the ancients. The rest are what they considered as *unformed stars.*

New stars sometimes appear while others disappear. Many stars which appear single to the naked eye are found to be double when viewed with a telescope. Some of them contain even three or four

stars. Dr. Herschel has discovered seven hundred of this discription.

The ancients divided the stars of the zodiack into the constellations in the following manner. As one of these stars rose, they set a vessel to receive the water, which slowly dropped from another vessel. The water which was thus obtained by the time the same star rose the next night, they divided into twelve parts, and poured again into the upper vessel. Small vessels each fitted to contain one part were then successively set to receive the dropping water. All the stars, which rose near the ecliptic while a vessel was thus filling, were considered as belonging to one constellation.

It is to be lamented that the constellations have not received names more suited to their grandeur, and to excite devotional feelings; but it will be remembered that they were given merely to assist the memory; that they are in no sense descriptive of the stars, and but very imperfectly so of the spaces they occupy, and that all these stars of light shine expressly for the purpose of glorifying their Creator.

The stars seem to change their relative situations every night. They are all ap-

parently whirled round the pole. Hence a star really north of another appears west of it, when they are at the east, and east of it when they are at the west; because they are on a line with the Polar Star. A star that appears south of another when rising will appear west of it near the meridian, and north of it when at the west, because they are on the opposite sides of a line drawn to the Polar Star. Thus Algol which is nearly south west of Perseus appears south east of it when they are at the east. To find what is the true relative situation of the stars you must consider that a straight line drawn in any direction from the Polar Star extends toward the south; and that the right hand of this line is east, and the left hand west; imagining yourself to be on the line with your face toward the pole.

CHAPTER XI.

DIRECTIONS FOR FINDING THE PLACES OF THE SUN, MOON, AND PLANETS.

By the Ephemeris, and the Calendar pages of an Almanack, you can find in what signs the Sun, Moon, and Superior

Planets are, together with their places, aided by the following statements.

The Sun is always about one hundred and twenty degrees west at eight o'clock, P. M.; or four signs west of the line, which passes over head at that time. It passes through a sign every month.

The Moon passes through all the signs every month, and one of them in about 2½ days. It is in the same sign with the Sun at its change.

Mercury is never as much as one sign from the Sun.

Venus at its greatest elongation is not more than 47 degrees and 48 minutes from the Sun—little more than a sign and a half.

The superior planets move toward the east; though they sometimes appear to be stationary, or retrograde.

Mars passes through about six signs a year.

Jupiter passes through a sign every year.

Saturn passes through a sign in about two years and a half.

Herschel passes through a sign in seven years.

The planets do not twinkle like the fixed stars; but shine with a steady light,

like the Moon. They are always in the constellations of the zodiack. When about three signs before or after the Sun, their motion so corresponds with that of the Earth as that they appear stationary. When passing from one station to another through their opposition to the Sun their motion is retrograde, at other times it is direct or toward the east.

CHAPTER XII.

THE DISTANCE OF THE FIXED STARS.

The Solar System is separated by an immense space from all the surrounding stars. The distance of the Sun and planets can be easily measured, and their magnitudes ascertained. But by no process can we determine the distance of even the nearest fixed stars. They seem diminished when viewed through a telescope which magnifies a planet *two hundred times*. Though Herschel's telescope which magnifies more than six thousand times increases their *blaze*, it does not discover their *disk*, nor furnish any assistance for discovering their magnitudes or distance.

The diameter of the Earth's orbit bears no perceptible comparison to their distance. Hence, from the law of vision, it is certain that their distance is at least a hundred thousand times the extent of that diameter.

Viewing an object at the south; and as you walk toward the east it will seem to move toward the west, if it is not very remote. By observing how far it has removed, and how far you have walked, you can determine its distance by the rules of geometry. But if the direction in which you view it, does not vary, you may be certain that it is vastly farther from you, than you have walked—a hundred thousand times farther, if no variation can be discovered by an accurate instrument.

But Sirius at the south, supposed to be the nearest fixed star, maintains precisely the same relative situation, it did six months ago; though since that time, we have moved to the west one hundred and ninety millions of miles, or the whole diameter of the Earth's orbit. It is therefore *nineteen billions* of mile from us; or a hundred thousand times *one hundred and ninety millions* of miles. Lines drawn to it from the extremities of the Earth's

orbit would seem parallel, forming no angle. But if they did form a small angle, say two seconds of a degree, and a calculation were made accordingly, you would find it to be so far off, that a cannon ball, flying at the rate of *four hundred and eighty miles an hour*, would not reach it in *four millions of years.* It is still farther than this—how much farther none can tell.

The fixed stars seem crowded together, especially the small ones, which compose the *Milky Way*, and other cloudy spots in the Heavens. But each one is probably, as far from all the rest, as the nearest is from our Sun; and is itself a centre to a system, like the Solar System—a Sun to revolving planets.

CHAPTER XIII.

THE NUMBER OF FIXED STARS.

The number of stars, visible to the naked eye, is small when compared with that which a telescope presents to view. Every improvement of the telescope has discov-

ered stars, not seen before, and numerous cloudy spots which seem to be stars, too remote to be distinctly visible. Hence the created universe seems to have no limits. God alone can tell the number of the stars. There are no bounds to space, nor to his creating power, and no reason appears why he should have so restricted the number of them, as that they could be computed by a finite mind.

The Heavens seem to be filled with clusters of stars; and every cluster, is supposed to be an immense system of Solar Systems.

Should you, moving like an unbodied spirit, direct your course to the nearest fixed star, it would increase to your view, till you would see planets rolling round it. On approaching it, it would become a resplendent universe. This world and all our planets would disappear; and the Sun itself become a mere point—a distant twinkling star. The same transition would take place, should you leave your new situation for the next star: that star would increase, become a Sun to revolving worlds, while the one you last left would dwindle into a point. It is probable you

might thus proceed with the rapidity of lightning, and at no assignable period reach the bounds of creation.

We have seen that the bodies of the Solar System are kept in their places by their centripetal and centrifugal forces. Every other system of worlds is probably balanced in the same way. But the systems themselves, if limited, must be drawn together by their mutual attraction; unless prevented by a projectile force, giving them a tendency to revolve round a common centre.

CHAPTER XIV.

THE INHABITANTS OF THE WORLDS INNUMERABLE.

The planets are evidently calculated and designed to accommodate rational beings. They are all like this Earth, and some of them vastly larger. They have day and night, summer and winter. Three of them at least have Moons to attend them. Many circumstances constrain us

to believe that they are filled with inhabitants; and that every fixed star illuminates worlds peopled with creatures like ourselves, but not involved with us in rebellion against the Creator—that there is peace in all his high places.

Jehovah intimates that it would have been inconsistent for him to create the Earth, had he not designed it to be inhabited. *He created it not in vain, he formed it to be inhabited.* As he shows us a number of other worlds, and gives us reason to believe that a far greater number are enlightened by the myriads of Suns, presented to our view, must we not infer from his perfections that he acted consistently in creating them, that he created them not in vain, but to be inhabited?

We are informed that *the morning stars sang together, and all the sons of God shouted for joy,* when he laid the foundations of this Earth. Hence intelligent creatures, and perhaps systems of worlds, previously existed. The declaration seems to intimate that the holy inhabitants of these early created worlds, as well as *the innumerable company of angels* rejoiced to see the new displays of power, wisdom,

and goodness, their creator made in bringing this world into existence. At least, there is reason to think, that such inhabitants are included in his *numberless armies* among *the principalities and powers in heavenly places.*

The descendants of Adam are numerous beyond our conception. But they probably bear no greater proportion in this respect, to the other subjects of God's moral government, than a drop does to the ocean, or the smallest particle of dust to the whole Earth. Were the Solar System with all its inhabitants struck out of existence, the loss would be comparatively no greater, than that of a single leaf in a boundless forest.

Every intelligent creature separately considered, is inconceivably valuable, in that he possesses immortal powers, and must exist in endlessly increasing bliss or woe, according to the character he forms while on trial. How immensely valuable then is the aggregate of the intelligent creation! But all are vanity when contrasted with the Creator. His powers, glory and happiness transcend theirs, as infinite space does a single point.

CHAPTER XV.

THE CONDESCENSION OF GOD.

The human race, though mean and worthless in comparison with the rest of of the universe, are not unnoticed by their Creator. With all the complicated and endlessly protracted concerns of creation devolving on him, he regards us individually as much, and is as attentive to our wants, as he should be, if he had no other charge.

But we have transgressed his holy law, on the honor of which the happiness of the universe depends. His benevolence therefore would have required that we should perish unless an adequate remedy were provided. For he could not otherwise pardon and save the guilty consistently with general justice. In this season of awful suspense his voice of mercy was heard—LIVE—I HAVE FOUND A RANSOM. *For God so loved the world that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life. Without controversy great is the mystery of Godliness: God was manifest in the flesh.* He

who created and upholds all things by the word of his power—*who being in the form of God, thought it not robbery to be equal with God, took on him the form of a servant; and was made in the likeness of men*, and passing by millions of other worlds, that needed no Saviour, he descended to this globe, suffered, and died, to save the rebellious inhabitants, who deserved to die. Thus he selected this small obscure part of his dominions as a theatre for displaying his perfections in the greatest of all his works—the work of redeeming love—a work which in its result will outshine that of creation itself; and resplendently manifest his glory through the universe—*To the intent that now unto the principalities and powers in heavenly places might be known by the church the manifold wisdom of God.*

"The first archangel never saw
"So much of God before."

The Moon and stars—the whole material and intellectual Creation is the effect of divine goodness. *The Lord hath made all things for himself—For his pleasure they are and were created;* for the gratification of his infinite benevolence. He is

full of compassion, ready to pardon, and save all who comply with his requisitions. But his word and providence declare, that he will never relinquish his claims as the Moral Governor of the souls he has made; nor bend his mighty movements to meet our puny plans. The worlds revolve, and the wheels of his providence roll on, as the highest good of the universe requires; and those who walk contrary to him must be crushed. If millions of men thus perish, the loss is as nothing, when contrasted with the interest of his vast and eternal empire; and desirable, considered as essential to that interest. But yield your powers to his command, and you may then humbly call him your God, and view the heavenly bodies, as they roll, and say they are yours, since they belong to your "Father and your Friend;" and realize that he, who arranged them in such perfect order, and fixed the laws by which they are governed, has pledged his veracity for your eternal protection and support.

> "The voice that rolls the stars along,
> Speaks all the promises."

GLOSSARY,

OR

EXPLANATION OF IMPORTANT TERMS

RELATING TO

ASTRONOMY.

Altitude, the height of a Heavenly body above the Horizon, reckoned on a vertical circle.

Amplitude, the distance of a Heavenly body, when rising or setting, from the east or west point in the Horizon.

Angle, the inclination of two lines meeting in a point. If one line be perpendicular to the other, the angle is 90° or a *right angle*.

Anomaly, a planet's distance from its aphelion

Aphelion, that point in the orbit of a Heavenly body which is farthest from the

Sun. The Earth is in Aphelion in July, for it is then at its greatest distance from the Sun. At the same time the Sun is in Apogee. The Earth's Aphelion moves at the rate of 1° 43′ 35″ in a hundred years. This is called its *secular motion.*

Apogee, the Sun's or Moon's greatest distance from the Earth. The Moon's Apogee moves round her whole Orbit in about nine years.

Area, the surface contained between any boundaries or lines. The Planets describe equal Areas in equal times. That is, straight lines considered as drawn from them to the Sun, and moving as they move, pass over just as much space one day as another. Hence the nearer they are to the Sun, the faster they move; and the reverse.

Astronomy, a science that relates to heavenly bodies.

Attraction of Gravitation, the tendency which bodies have to approach one another without any apparent cause.

Axis, the imaginary line about which a globe or circle rolls.

Bissextile, (twice six) leap year, when a day is added to February, but when the

Romans used to reckon the sixth day of the Calends of March twice over.

Central Forces, the composition of two forces, by which a body moves in a circle or curve. One force tending to draw it toward the centre, and the other to throw it forward, it can only move in a middle course between them, so as to describe a circle or curve.

Centrifugal Force, the force by which a revolving body tends to move forward in a straight line away from the centre.

Centripetal Force, the force which draws a revolving body toward the centre.

Conjunction. Two heavenly bodies are in conjunction when they are in the same longitude, or when they appear in the same direction.

Copernican System, the present system of Astronomy. It was taught by Pythagoras five hundred years before Christ, and revived in the sixteenth century by Copernicus.

Cycle of the Moon, or *the Golden Number*, is a revolution of nineteen years, when the Moon returns again to its same relative situation with respect to the Sun and signs. Its conjunctions, oppositions,

and other aspects are within an hour and a half of being the same as they were on the same days of the month nineteen years before. The reason of this revolution is that the Sun attracts the Moon, when she is north or south of the Ecliptic, and causes her to return to it again sooner than she otherwise would.

Cycle of the Sun, a period of twenty-eight years, when the days of the month return to the same days of the week, and the Sun's place to the same degrees of the Ecliptic on the same months and days.

Day (sidereal,) 23 h. 56 m. 6 sec. or the rotation of the Earth.

Day, (solar,) the time from noon to noon.

Day, (civil,) from midnight to midnight.* A day in the history of creation means light considered as divided into evening and morning. Or the time in which light from its eastern to its western extremity performed one revolution round the earth. "God called the light day." And the evening and the morning were the first day.

Declination, the distance of a heavenly body from the Equator. When the Sun

* A civil day is reckoned differently by different nations.

declines 23° 28′ from the Equator, it meets a Tropic, and returns.

Degree, the three hundred and sixtieth part of a circle. Hence a degree is great or small according to the circle. A degree of a great circle of the Earth is sixty-nine miles. But a degree of longitude in latitude 42° is about fifty-one miles. For circles around the Earth parallel to the Equator, grow less and less toward the north and south Poles. Fifteen degrees in the heavens is about as far as the sun seems to move in an hour. For it is the twenty-fourth part of three hundred and sixty.

Diameter, a straight line extending through the middle of a circular figure or globe.

Digit, the twelfth part of the Sun's or Moon's diameter. The term is also applied to that part of the Earth's shadow, by which the Moon, is eclipsed. If this be wider than the Moon the eclipse is more than twelve digits.

Disk, the face or apparent surface of a heavenly body.

Dominical Letter, one of the seven first letters of the alphabet, used for the pur-

pose of showing on what day of the month the first Sabbath of the year falls.

Eccentricity, the distance between the real centre of an Ellipse and either of its Foci.

Ecliptic, a circle around the heavens in which the Sun seems to pass every year. It is called by this name because the Moon is always in or near the plane of it, at the time of an eclipse of the Sun or Moon.

Ellipse, is an oval figure or a circle so prolonged as to have two centres or foci. The Orbit of every Planet is an Ellipse having the Sun in one of its foci. Hence the Planets are once in Perihelion and once in Aphelion during every revolution round the Sun. Their distance from the Sun, which is between these two extremes, is called their *mean distance.* Thus the *mean* distance of the Earth is ninety-five million of miles, because it is at that distance when half way between its Aphelion and Perihelion.

Elongation, the apparent distance of a Planet from the Sun.

Epact, the Moon's age at the end of the year; or the difference between the Lunar and Tropical year.

Ephemeris, an account of the daily motions of the Planets, with respect to the Signs.

Equinoxes, the beginning of Aries and Libra, where the Sun crosses the Equator.

Galaxy, the Milky Way, a white track in the heavens, occasioned by myriads of Stars too small to be distinctly seen.

Hemisphere, half a sphere or globe.

Latitude, the distance north or south of the Equator.

Latitude, (celestial,) the distance north or south from the Ecliptic. Hence a heavenly body north of the Equator is in south latitude, if it be on the south side of the Ecliptic.

Longitude, the distance east or west. Fifteen degrees of Longitude make an hour's difference in time. Thus, when it is noon here, it is one o'clock fifteen degrees east, and eleven o'clock fifteen degrees west, &c.

Longitude, (celestial,) the distance east from the first of Aries reckoned on the Ecliptic. Hence the last degree of Pisces is the three hundred and sixtieth degree east Longitude.

Horizon, (rational,) a circle which di-

vides the Earth and Heavens into upper and lower hemispheres.

Horizon, (senseable,) the circle where the Heavens and Earth appear to meet.

Mean distance, time or motion, is that which is between the two extremes.

Meridian, a straight line passing from the north to the south pole. The Meridian of any particular place passes through the Zenith of that place. Thus the Sun is on our Meridian at noon. A Star is likewise on our Meridian, though north of us, if it be directly between us and the pole.

Month, (Lunar,) 27 days, 7 h. 43 m. the time in which the Moon passes from a point in her Orbit to the same point again.

Month, or *Lunation,* 29 days, 12 h. 44 m. 3 seconds, or the time from one new moon to another.

Month, (Calendar,)

Thirty days hath September,
April, June and November.
February has twenty-eight alone,
All the rest have thirty-one.

Motion, (secular) is the progression which the Aphelion and Perihelion make in a hundred years. These points in the

Earth's Orbit move in that time 1° 43′ 35″. Hence they will perform a revolution round the Ecliptic in 20,700 years if the world should continue ; and when half of that time is elapsed, the Sun will be in Perigee the first of July.

Nadir, the point under foot directly opposite to the Zenith.

Nebulæ, clusters of exceedingly small stars. Dr. Herschel with his mighty telescope has discovered more than two thousand of them. Each of these spots is probably as large as the Milky Way, which he supposes includes the Sun and all the Stars of the first, second and third magnitude.

Nodes, the two points in which the Orbit of the Moon or a Planet crosses the plane of the Ecliptic. The Moon is never more than five and a half degrees from the Ecliptic. Hence it runs high and low every month.

Nutation of the Poles. The Earth's Axis changes its inclination to the plane of the Ecliptic twice a year. Hence its Poles nod, or have a nutation. This is caused by the accumulation of matter about the Equator, which the Sun attracts

when north and south of it. [See Chapter X.]

Opposition. When a heavenly body is 180° from the Sun, it is in opposition to it.

Parallax, the difference between the apparent directions of a heavenly body as seen from different stations.

Penumbra. The dark part of the Earth's shadow is called its Umbra, and the light part its Penumbra.

Perigee, that point in which a heavenly body is nearest to the Earth. The Perigee of the Moon or a Planet is always six signs from its Apogee.

Perihelion, the point in the Orbit of a heavenly body which is nearest to the Sun. The Earth is in its Perihelion in January. At the same time the Sun is in its Perigee. Most of the Sun's rays, which reach the Earth in the winter, fall to the south of us, and the rest strike us obliquely. Hence it is colder than in the Summer, though the Sun is nearer to the Earth.

Periodical Time, is the time in which a Planet performs its revolution round the Sun. The squares of the Periodical times of the Planets are as the cubes of their

mean distance from the Sun. From this law the relative distances of the Planets have long been known. Hence it was only necessary to find the distance of one of them in order to find the distance of the rest. By the transit of Venus over the Sun in 1761 and 1769, the distance of that Planet was ascertained. From that the distances of the other Planets have been accurately calculated.

Plane. The Plane of a circle or an ellipse is its imaginary surface. The Plane of the ecliptic or the Earth's Orbit is considered as indefinitely extended. It not only passes from the Sun through the Earth, but it extends to the fixed Stars. Bodies directly over or under the Earth's Orbit are in its plane, however distant.

Poles, the extremities of the Axis. The Poles of the Ecliptic are 23° 28′ from those of the Equator or the Earth ; for the Axis of the Earth is inclined toward the Plane of the Ecliptic. This inclination is diminishing at the rate of fifty seconds of a degree in a hundred years.

Refraction. Rays of light are refracted, or bent out of their course, when they enter obliquely from a rarer into a denser medium. This is the reason that

heavenly bodies near the Horison appear higher than they are in reality.

Retrograde, the motion which planets sometimes appear to have toward the west contrary to the order of the signs. They are all retrograde every year.

Revolution. A globe performs a revolution when it moves once round its orbit, and when it turns once round on its axis. Its revolution on its axis is usually called its ROTATION.

Right Ascension, of a heavenly body is the distance of its meridian east from the first of Aries, reckoned on the Equator.

Signs, 12 divisions of the Zodiack, reckoned from the point, where the sun crosses the Equinoctial line in March, called Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces. Each extends 30° from west to east.

Solstices, two points in the Ecliptic, at its greatest distances from the Equator. The summer Solstice is in Cancer, where the sun is June 21. The winter Solstice is in Capricorn, where the sun is Dec. 22. Two circles passing through these points parallel to the Equator, are called *Tropics*. Their planes include the *Torrid Zone*.

Year (Periodical or Sidereal) 365 days 6 h. 9 m. 14½ s the time in which the Earth completes a revolution round its orbit, so as to return again to the same fixed star.

Year, (Tropical) 365 d. 5h. 49 m. the time in which the Sun passes from a Tropic to the same again. This is the real year. It is about 20¼ minutes shorter than the Earth's periodical time; because the Sun, after leaving a Tropic, or an Equinox, returns to it again, while the Earth has not got round its orbit by 50 seconds of a degree. This causes the Precession of the Equinoxes.

Year, (Julian or civil,) 365 days, 6 h. The year thus fixed by Julius Cæsar is 11 minutes too long. Hence in the course of ages the days of the months varied with respect to the Equinoxes and Tropics. To correct this variation, and to prevent it for the future, the new style was adopted A. D. 1752; and arrangements made for omitting the Bissextile day at the commencement of three centuries out of four.

Zenith, the point overhead, or the upper Pole of the Horizon.

Zodiack, a space round the heavens, including 8° each side of the Ecliptic, and the orbits of all the Planets.

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