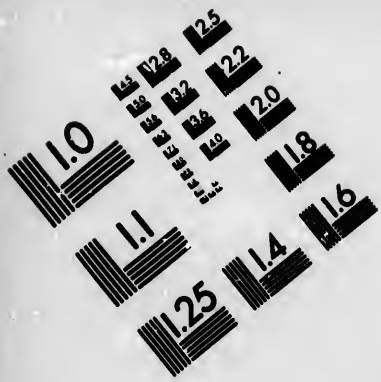

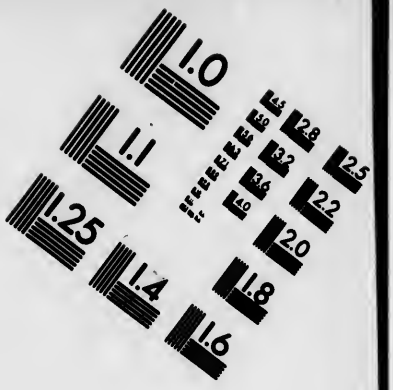

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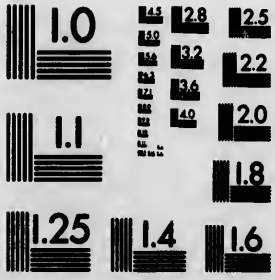

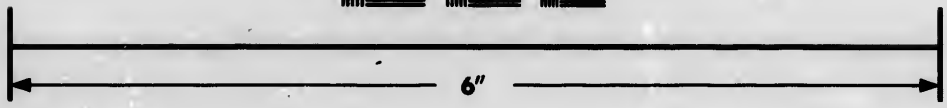

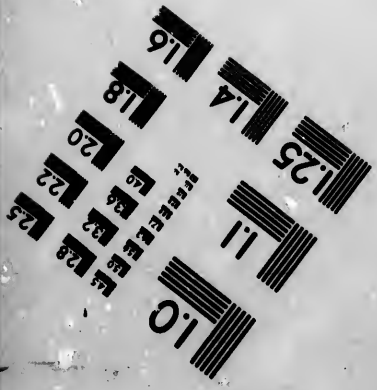

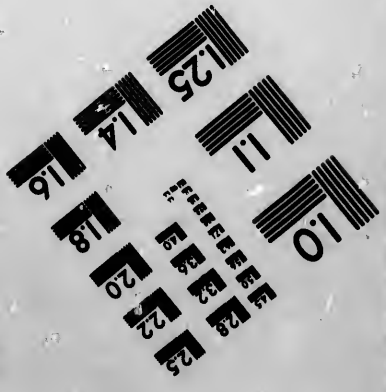

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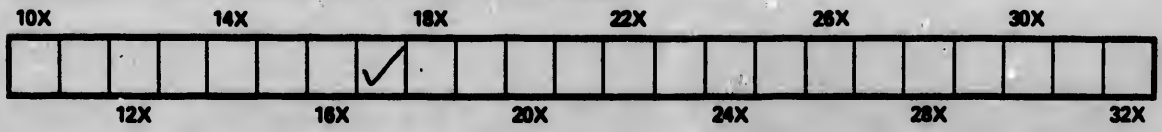
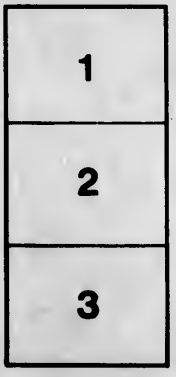
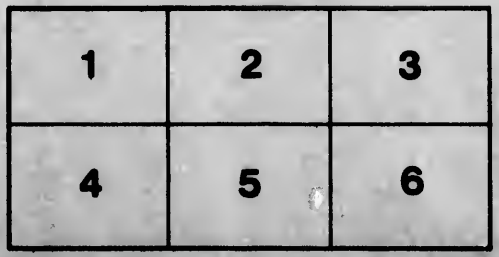






AN ABRIDGMENT

OF

SMITH'S

ILLUSTRATED ASTRONOMY.

DESIGNED FOR THE USE OF

JUNIOR CLASSES

IN THE

PUBLIC OR COMMON SCHOOLS.

Toronto:

WILLIAM WARWICK, WELLINGTON STREET, EAST

1876.

NOTICE.

The following treatise is intended to include a systematic exposition of the appearances and laws of the heavenly bodies, as far as is practicable without the aid of Geometry, Algebra, and the higher Mathematics.

Several diagrams are inserted, which will be acceptable, both to teachers and pupils, in illustrating the general principles of Astronomy, which, without illustrations, are deprived of much that is pleasing to the eye, and instructive to the understanding.

GEOMETRICAL DEFINITIONS.

THE Teacher should require the Pupils to understand the following Geometrical Definitions, before they are allowed to proceed with the following Lessons:—

A Straight Line is the shortest line that can be drawn between any two points.

A Surface is that which has length and breadth; but no thickness.

A Plane is a straight, even surface. The plane of a circle, is the surface contained within it, and continued out of it on all sides, indefinitely. The *top* of a round centre table, may be said to represent the plane of a circle.

Parallel Lines are lines continued in the same direction, and at the same distance from each other. They may be either straight or curved lines.

A Circle is a plane figure, bounded by a curved line, every part of which is equally distant from the centre.

The Diameter of a Circle is a straight line, passing through the centre, and terminating both ways by the circumference.

The Circumference of a Circle is the curved line which bounds it.

The Circumference of every Circle is supposed to be divided into 360 equal parts, called *degrees;* each degree, into 60 equal parts, called *minutes*, and each minute into 60 equal parts, called *seconds*.

The Radius of a Circle is a straight line, drawn from the centre to the circumference.

A Quadrant is a quarter of a circle, and contains 90 degrees.

A Semi-circle is the half of a circle, and contains 180 degrees.

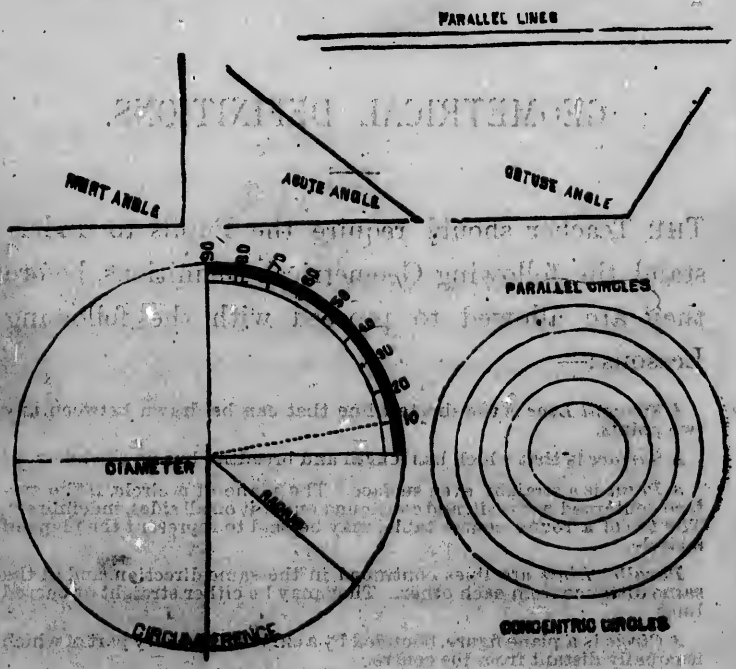
An Angle is formed by one line, meeting another, at a point.

A Right Angle is an angle which contains 90 degrees, or a quarter of a circle.

An Acute Angle is an angle which contains less than 90 degrees.

An Obtuse Angle **is an angle which contains more than 90, and less than 180, degrees.**

Parallel, or Concentric Circles, **are two or more circles drawn around the same centre.**



ABRIDGMENT

OF

Smith's Illustrated Astronomy.

LESSON I.

QUESTION. What is the body called upon which we live?

ANSWER. It is called the EARTH, or WORLD.

Q. What idea had the ANCIENTS respecting the shape of the earth?

A. They believed it was an extensive plain, rendered uneven by hills and mountains.

Q. Why did they think it was an extended plain?

A. Because they formed their opinions from appearances only.

Q. Did they believe that the earth had any motion?

A. They did not; they believed that the earth rested on a solid, immovable foundation.

[They very naturally came to this conclusion, as they were entirely ignorant of the laws of attraction or gravitation. They believed if the earth were to turn over, that every thing would be precipitated from its surface.]

Q. Had they any definite ideas respecting what held the earth up?

A. Their views were very vague and unsatisfactory.

[There have been many absurd ideas advanced, at different ages of the world, as to what supported the earth. Some sup-

posed it to be shaped like a CANOE, and to float upon the waters; others, that it rested upon the back of an ELEPHANT, or huge TURTLE; while according to mythology, ATLAS supported it upon his shoulders; but, what kept the waters in their place, or upon what the Elephant, Turtle, or Atlas stood —this was a mystery they COULD NEVER SOLVE.]

Q. Did they believe the earth extended the same distance in all directions?

A. They believed it to extend much farther from east to west than from north to south.

[They observed that in going east or west, on the same parallel of latitude, no change took place in the appearance of the heavens; but in going north or south, on the same meridian, every sixty miles caused a difference of one degree in the elevation of the pole, and in the position of the cicles of daily motion of the sun and other heavenly bodies; therefore they concluded that the earth was very long from east to west, but comparatively narrow from north to south. From this originated the use of the terms longitude and latitude; longitude meaning length, and latitude, breadth.]

Q. What ideas had they respecting the motions of the sun, moon, and stars?

A. They supposed that they revolved around the earth, from east to west, every day.

Q. What was this system called, that supposed the earth to be at rest in the centre, and all the heavenly bodies to revolve round it?

A. The Ptolemaic * system.

[Ptolemy asserted that the sun, moon, planets, and stars revolved around the earth, from east to west, every 24 hours; and to account for their not falling upon the earth, when they passed over it, he supposed that they were each fixed in a separate hollow crystalline globe, one within the other. Thus the moon was in the first; Mercury in the second; Venus in the third; the sun in the fourth; Mars in the fifth; Jupiter in the sixth; Saturn in the seventh;—(the planet Herschel was not known at this time)—the fixed stars in the eighth. He supposed the stars to be in one sphere, as they are kept in the same positions with respect to each other. To permit the light of the stars to pass down to the earth, he supposed these spheres or globes were perfectly clear or transparent like glass. The power which moved these spheres, he supposed, was communicated from above the sphere which contained the stars.]

* Tole-ma'-ic.

LESSON II.

QUESTION. Every one is conscious that the sun, which rises daily in the east and sets in the west, is the same body; where does it go during the night?

ANSWER. It appears to pass round under the earth.

Q. When we look out upon the stars, on successive evenings, they appear to have a definite position with respect to each other, and a westward movement like the sun; what motion do they appear to have from their setting to their rising?

A. They appear to pass under the earth.

Q. From the north to the south point of the heavens, there is a continuous arc of stars, and in their passage under the earth they are not at all disarranged, what can you infer from this fact?

A. That they pass completely around the earth, and every thing attached to it.

Q. We see no body at rest that does not touch some permanent support, but we see bodies in motion supported for different lengths of time without resting upon any other surface; if the earth is hung upon nothing, is it probably at rest?

A. It is more probable that it is in motion.

Q. If we throw a ball, does the same side always remain forward?

A. It does not; it turns over continuously.

Q. What do we call the line round which it turns?

A. Its axis.

Q. If a fly were on the ball, would distant objects appear to him to be stationery?

A. They would appear to revolve around the ball, as often as it turned over.

Q. If the earth is moving in space, is it in accordance with the known motion of ordinary bodies, to suppose that the same side remains forward?

A. It is not. It is more reasonable to suppose that it turns on its axis.

Q. If the earth turns, and we are carried round on its surface, what appearance must the sun and distant stars necessarily present?

A. They must appear to move around the earth in the opposite direction.

LESSON III.

QUESTION. What other reason can you give for the earth's turning?

ANSWER. The stars are so distant, that their motion would be immensely swift, in comparison with the motion of the earth, to produce the same effect.

Q. But have we not positive proof, and that too of different kinds, that the earth turns on its axis?

A. We have.—1. The shape of the earth, elevated at the equator and depressed at the poles, can be accounted for on no other supposition.

2. A body at the equator, dropped from a great height, falls eastward of the perpendicular.

3. The trade winds and ocean currents in the tropical regions are clearly traceable to the same cause.

Q. If the earth is moving in space, does it proceed in a straight line?

A. It does not; but it would do so, were it not attracted by other bodies.

Q. What is the attraction, by which all particles of matter tend towards each other, called?

A. The attraction of gravitation.

Q. What large body, by its attraction, causes the earth to revolve around it in a curved line.

A. The sun.

Q. What other similar bodies revolve around the sun?

A. The planets.

Q. What may we call the earth, when considered with regard to its size, shape, motions, etc.

A. One of the planets.

Q. What science describes these characteristics of the earth and other heavenly bodies?

A. Astronomy.

LESSON IV.

ASTRONOMY.

QUESTION. What is Astronomy?

ANSWER. Astronomy is the science which treats of the heavenly bodies.

Q. What are the heavenly bodies?

A. The sun, moon, planets, comets, and stars.

Q. Are they all of the same magnitude, or size?

A. The sun and stars are much larger than the other bodies.

Q. Are they all at the same distance from the earth?

A. They are not; the moon is the nearest, and the stars the most distant.

Q. Do they all emit light of themselves?

A. They do not.

Q. How are they divided in this respect?

A. They are divided into two classes, luminous and opaque.

Q. What is a luminous body?

A. It is a body which shines by its own light.

Q. What is an opaque body?

A. It is a body which shines only by reflecting the light of a luminous body.

Q. Which are the luminous bodies in the heavens?

A. The sun and fixed stars are luminous bodies.

Q. Which are the opaque bodies in the heavens?

A. The moon, planets, and comets.

Q. Why do the moon, planets, and comets appear luminous?

A. Because they reflect to us the light of the sun.

Q. What is the shape of the heavenly bodies?

A. They are round like a globe or ball.

Q. What do the sun, moon, planets, and comets constitute?

A. They constitute the solar system.

LESSON V.

THE SOLAR SYSTEM.

QUESTION. How are the bodies constituting the solar system arranged?

ANSWER. The sun is placed in the centre of the system, with the planets and comets revolving around it at unequal distances.

Q. How many planets are there in the solar system?

A. Thirty-six is the number known at present.

Q. How are they divided with respect to their motion?

A. They are divided into two classes, primary and secondary.

Q. What is a primary planet?

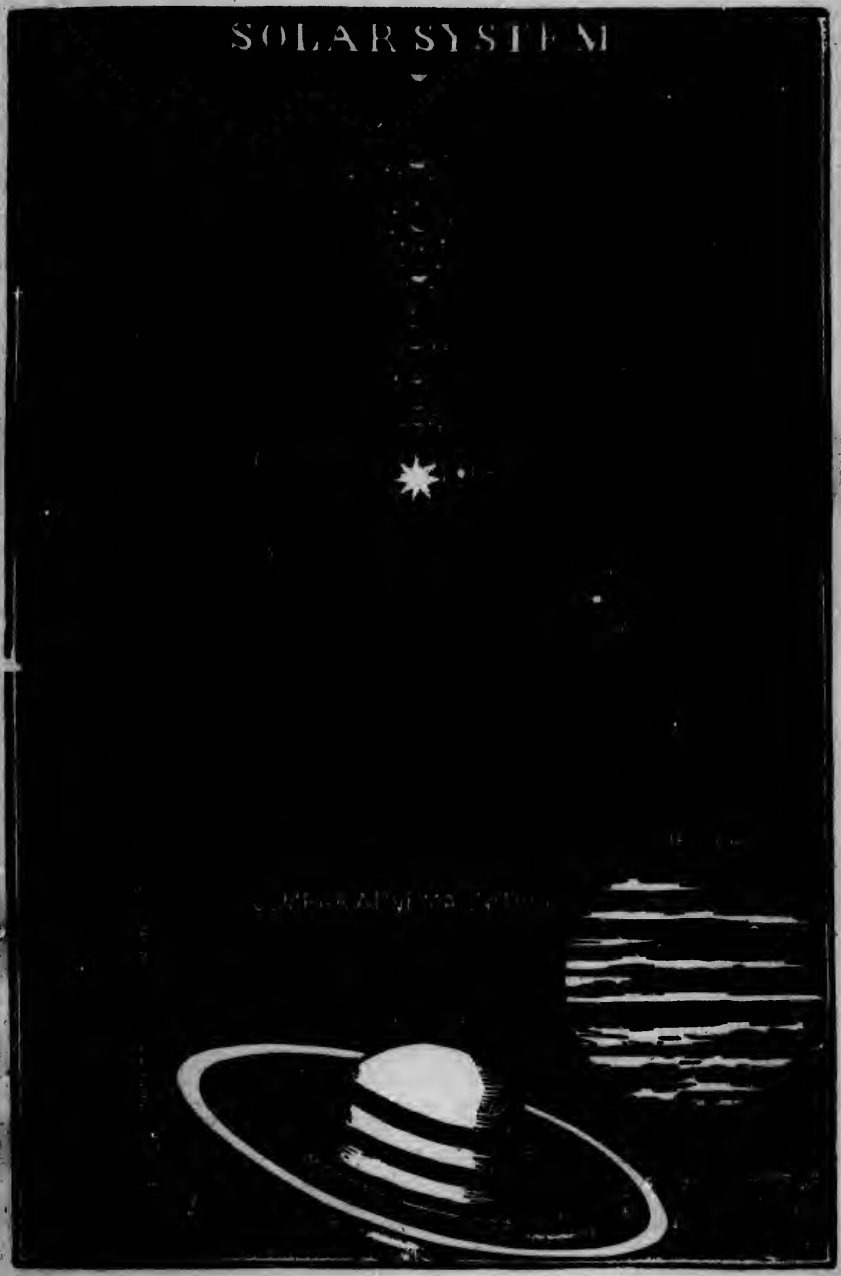
A. It is a planet which revolves around the sun only.

Q. What is a secondary planet?

A. It is a planet which revolves around its primary, and with it around the sun.

Q. What are the secondary planets usually called?

A. They are called satellites or moons.


SOLAR SYSTEM

Q. How many primary planets are there?

A. Sixteen; eight being asteroids or small planets.

Q. What are their names, beginning at the sun?

A. Mercury, Venus, the Earth, Mars, (Vesta, Astræa, Juno, Ceres, Pallas, Hebe, Iris, Flora,) Jupiter, Saturn, Herschel, or Uranus, and Leverrier, or Neptune.

Q. How many secondary planets or moons are there?

A. Twenty.

Q. Which planets have moons?

A. The Earth has 1, Jupiter 4, Saturn 8, Herschel 6, and Leverrier 1.

Q. In what direction do all the planets revolve on their axis, and around the sun?

A. From west to east.

[*Note.*—In examining the Solar System, an arrangement of extraordinary beauty and harmony, presents itself. The Sun, which is 500 times larger than all the planets, both primary and secondary, combined, occupies the centre, diffusing light and heat in all directions. A curious and extraordinary law seems to regulate the distances and motions of all the planets. The following are some of their peculiarities, viz:—

1st. The Sun, which occupies the centre, revolves on its axis from *west* to *east*.

2d. All the primary planets revolve around the Sun in the same direction, from *west* to *east*.

3d. The secondary planets or moons, revolve around their primaries from *west* to *east*.

4th. All the planets, both primary and secondary, revolve on their axis from *west* to *east*.

5th. The orbits of all the planets, both primary and secondary, lie nearly in the same plane of the Sun's equator.

From this it will be seen that all the motions of the planets in our solar system are in one direction; a circumstance which clearly demonstrates, that they originated from the same cause and are governed by the same laws. To this remarkable harmony in the movements of our Solar System, there is supposed to be one exception, viz., the retrograde motion of the Satellites of Uranus. But this fact has not been fully settled by Astronomers. For a more full description of the origin of the Solar System, see Illustrated Astronomy, page 47.]

LESSON VI.

QUESTION. How many revolutions has a primary planet?

ANSWER. Two; one on its axis, and another around the sun.

Q. What is the axis of a planet?

A. It is a straight line, round which it turns.

Q. What is the path called, in which a planet revolves around the sun?

A. It is called its orbit.

Q. What is the plane of the earth's orbit, extended to the heavens, called?

A. It is called the ecliptic.

Q. Why is it so called?

A. Because eclipses take place only when the moon is in its plane.

Q. How many revolutions has a secondary planet?

A. Three. 1st, the revolution upon its axis; 2d, the revolution around its primary; 3d, the revolution with its primary around the sun.

Q. How are the planets divided, with respect to their distance from the sun?

A. Into inferior and superior, according as their distance from the sun is inferior or superior to that of the earth.

Q. Which are the inferior planets?

A. Mercury and Venus.

Q. Which are the superior?

A. Mars, the Asteroids, Jupiter, Saturn, Herschel, and Leverrier.

Q. How many kinds of conjunction are there?

A. Two; inferior and superior.

Q. When is a planet in inferior conjunction with the sun?

A. When it is between the earth and sun.

Q. What planets can be in inferior conjunction?

A. Mercury and Venus; also the moon.

Q. When is a planet in superior conjunction?

A. When the earth and planet are on opposite sides of the sun.

Q. What planets can be in superior conjunction with the sun?

A. All the planets except the earth and moon.

Q. When is a planet in opposition.

A. When the earth is between the sun and planet.

Q. What planets can have opposition?

A. The superior planets.

LESSON VII.

	Diameters.	Magnitudes; the Earth being 1	Distances from the Sun.	Revolution on their axis.	Revolution around the Sun.
	Miles.		Miles.	Dys. hours.	Yrs. Days.
Sun,	886,952	1,384,472		25 10	
Mercury,	3,200	..... $\frac{1}{17}$	37,000,000	24	88
Venus,	7,700	..... $\frac{9}{10}$	68,000,000	23½	224
Earth,	7,912	 1	95,000,000	24	1 0
Mars,	4,189	..... $\frac{1}{7}$	142,000,000	24½	1 321
Vesta,	270	..... $\frac{1}{25000}$	225,000,000	Unknown.	3 230
Astræa,	unknown	Unknown.	253,000,000	"	4 105
Juno,	1,400	..... $\frac{1}{150}$	254,000,000	"	4 131
Ceres,	1,600	..... $\frac{1}{125}$	263,000,000	"	4 222
Pallas,*	2,100	..... $\frac{1}{55}$	263,000,000	"	
Hebe,	unknown	Unknown.	Unknown.	"	
Iris,	"	"	"	"	
Flora,	"	"	"	"	
Jupiter,	87,000	1,280	485,000,000	10	11 314
Saturn,	79,000	1,000	890,000,000	10½	29 16
Herschel,	35,000	80	1,800,000,000		84 5
Leverrier,	35,000	80	2,850,000,000		166

* Herschel estimated the diameter of each of the asteroids to be under 200 miles. Their great distance, extreme smallness, and nebulous appearance, render it extremely difficult to ascertain their size with accuracy.

LESSON VIII.

CENTRIPETAL AND CENTRIFUGAL FORCE.

QUESTION. What is that force called with which all bodies attract each other in proportion to their mass?

ANSWER.—The attraction of gravitation.

Q. What is centripetal force?

A. It is the force which draws a body towards the centre round which it is revolving.

Q. What large body, by its attraction, exerts a centripetal force upon all the primary planets and comets?

A. The sun.

Q. What body exerts a centripetal force upon the moon?

A. The earth.

Q. What bodies exert a centripetal force upon the other moons?

A. The primary planets around which they revolve.

Q. What is the centrifugal force of a heavenly body?

A. It is that force which moves it forward in its orbit.

Q. How do these two forces cause the planets to move?

A. They cause them to move in circular or, elliptical orbits.

[A body projected by any force would always move forward in a straight line, and with the same velocity, unless acted upon by some other force. A ball discharged from a gun or thrown from the hand soon looses its projectile force by the resistance of the atmosphere, and is brought to the ground by the attraction of the earth, or centripetal force. (FIG 8.) These two forces can be well illustrated, (SEE FIG. 1, 2,) by tying a string to a ball and swinging it around; the centrifugal force imparted to the ball by the hand and by means of the string, causes the ball to move in a circle; but if the string should break, the centrifugal force would carry it off in a straight line, if the ball was not attracted by the earth. The string corresponds to the attraction of the sun in our solar system, which causes the

planets to move in regular curves around the sun, instead of straight lines. If the attraction of the sun or centripetal force should cease, the planets would fly off into space in straight lines; but if the centrifugal force should cease, and the centripetal force continue, the planets would immediately fall into the sun.]

Q. What is a circle?

A. It is a plane figure bounded by a curve line, all parts of which are equally distant from the centre.

Q. What is an ellipse?

A. It is an oval figure, represented by an oblique view of a circle.

[*Note.*—Teachers should be sure that the pupils understand the definition of an ellipse, because in viewing some of the diagrams they may receive a wrong impression. In the diagram representing the seasons, the earth's orbit appears very elliptical: this would be well understood by the pupil, should the teacher call his particular attention to it. Also, a plane of a circle should be well understood.]

Q. What are the foci of an ellipse?

A. They are the two points, around which the ellipse is drawn, and are equally distant from the centre.

Q. Where is the sun situated within the orbit of each planet?

A. It is situated, not in the centre; but in the lower focus.

Q. What is the shape of the orbits of all the planets?

A. Elliptical, or longer one way than the other.

THE MEAN AND TRUE PLACE OF A PLANET.

Q. What is the mean place of the earth, or a planet in its orbit?

A. It is that point in its orbit where it would be if it moved in a circle, and with the same velocity at all times.

Q. What is the true place of the earth or a planet?

A. It is that point in its orbit where it really is at any given time.

Q. What is the aphelion?

A. It is that point in the orbit of the earth or planet farthest from the sun.

Q. When is the earth in the aphelion or farthest from the sun?

A. July 1st.

Q. What is the perihelion?

A. It is that point in the orbit of the earth or planet nearest to the sun.

Q. When is the earth in the perihelion, or nearest to the sun?

A. January 1st.

LESSON IX.

THE SUN.

QUESTION. What body is the centre of the solar system?

ANSWER. The sun.

Q. Describe the sun?

A. The sun is a large luminous body, which gives light and heat to the whole solar system.

Q. What is the diameter of the sun?

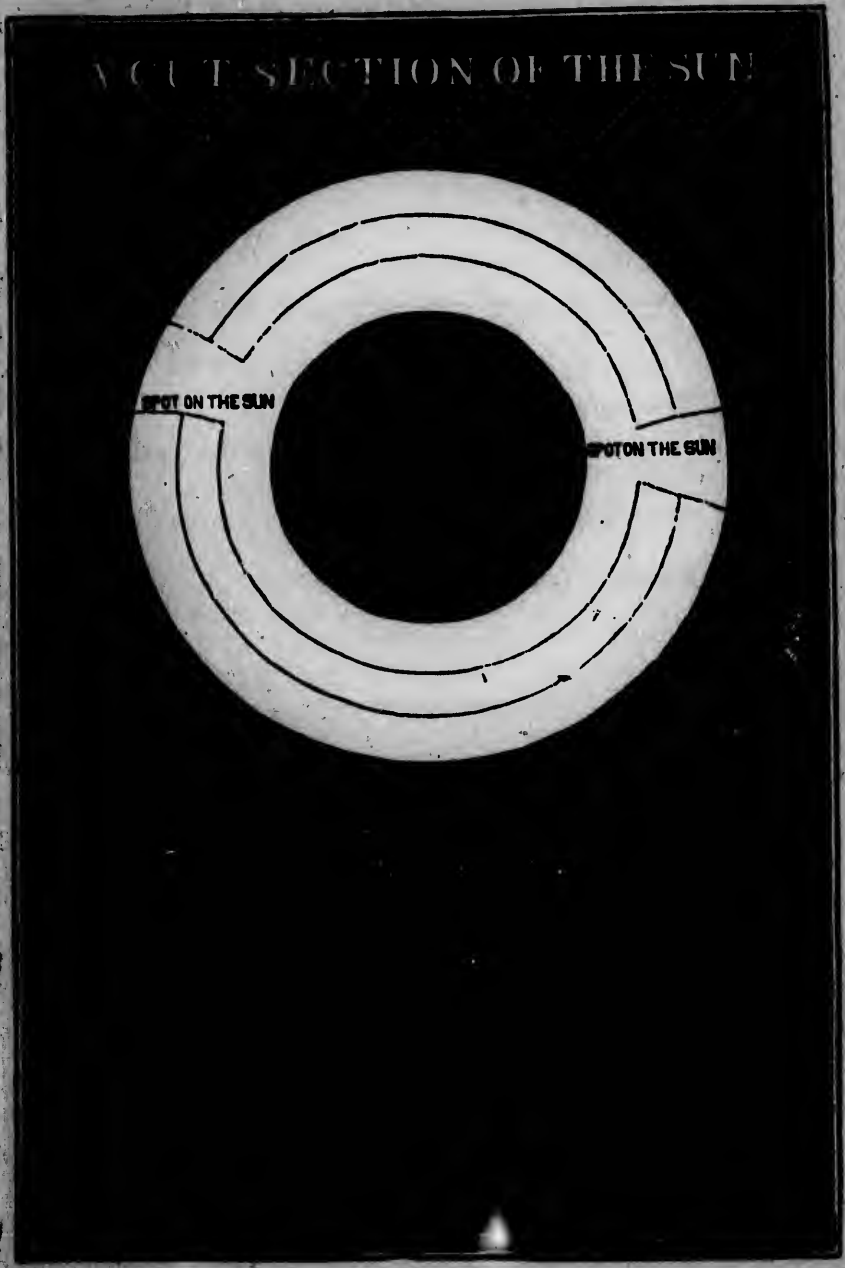
A. 886,952 miles.

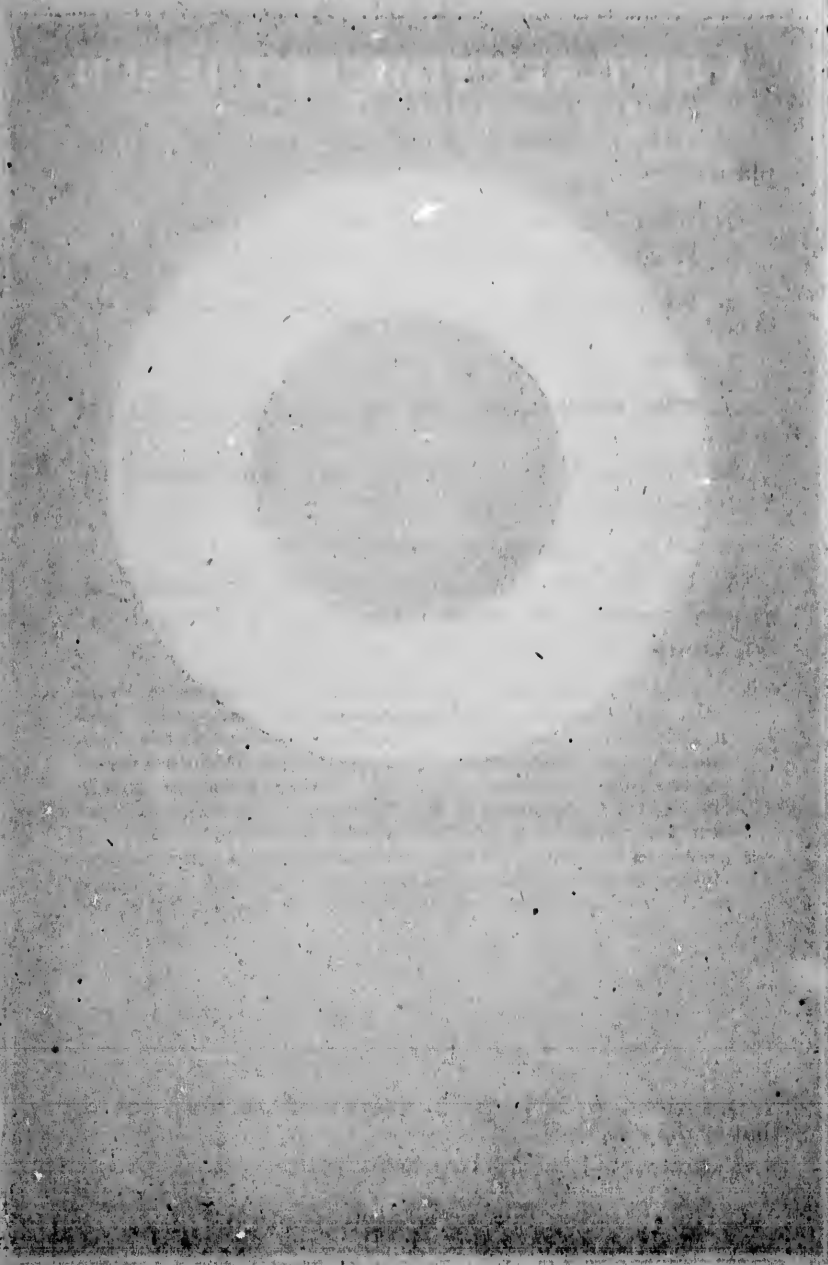
Q. How much larger is the sun than the earth?

A. It is 1,384,472 times greater.

Q. What is the size of the sun compared with the planets?

A. It is 500 times as great as the bulk of all the planets.


A CUT SECTION OF THE SUN
SPOT ON THE SUN
SPOT ON THE SUN



Q. What can you say of its mass or weight?

A. It is about 750 times the mass of all the planets.

Q. What is the distance of the sun from the earth?

A. It is about 95,000,000 of miles.

Q. What did the ancient astronomers consider the sun to be?

A. A large globe of fire.

Q. What do astronomers at the present day consider it to be?

A. An opaque body like the earth, surrounded by a luminous atmosphere.

Q. What motions has the sun?

A. It has three motions—1st, on its axis; 2d, around the centre of gravity of the solar system; 3d, around the centre of the universe.

[The term universe is used by Astronomers, though perhaps improperly, to designate the great cluster or firmament of stars in which our sun is situated. This cluster includes all the single stars that can be seen with the naked eye, and all those composing the galaxy or milky way. The number of stars or suns in the cluster is estimated at many millions; all which, like our sun, are supposed to revolve around the common centre of gravity of the whole cluster. Several thousand other distinct clusters or nebulæ, situated without our firmament, can be seen by the best telescopes, nearly all of which are invisible to the unassisted eye.]

LESSON X.

QUESTION. What is the inclination of the sun's axis to that of the ecliptic?

ANSWER. About 7½ degrees.

Q. In what time does it revolve on its axis?

A. In about 25 days and a half.

Q. How is the revolution of the sun on its axis determined?

A. By spots on its surface, which first appear on the east side, pass over, and disappear on the west side.

Q. What is the nature of these spots?

A. They are supposed to be openings in the luminous atmosphere, which enable us to see the dark body of the sun.

Q. What occasions these openings in the luminous atmosphere?

A. They have been attributed to storms and various other causes.

Q. Do these spots undergo any changes?

A. They are constantly changing, and sometimes very rapidly. Some have appeared, others disappeared suddenly.

Q. On what part of the sun do they appear?

A. Within about thirty degrees of its equator.

Q. Is the surface of the sun, in the region of the spots, tranquil or agitated?

A. It is in a state of continual and violent agitation.

LESSON XI.

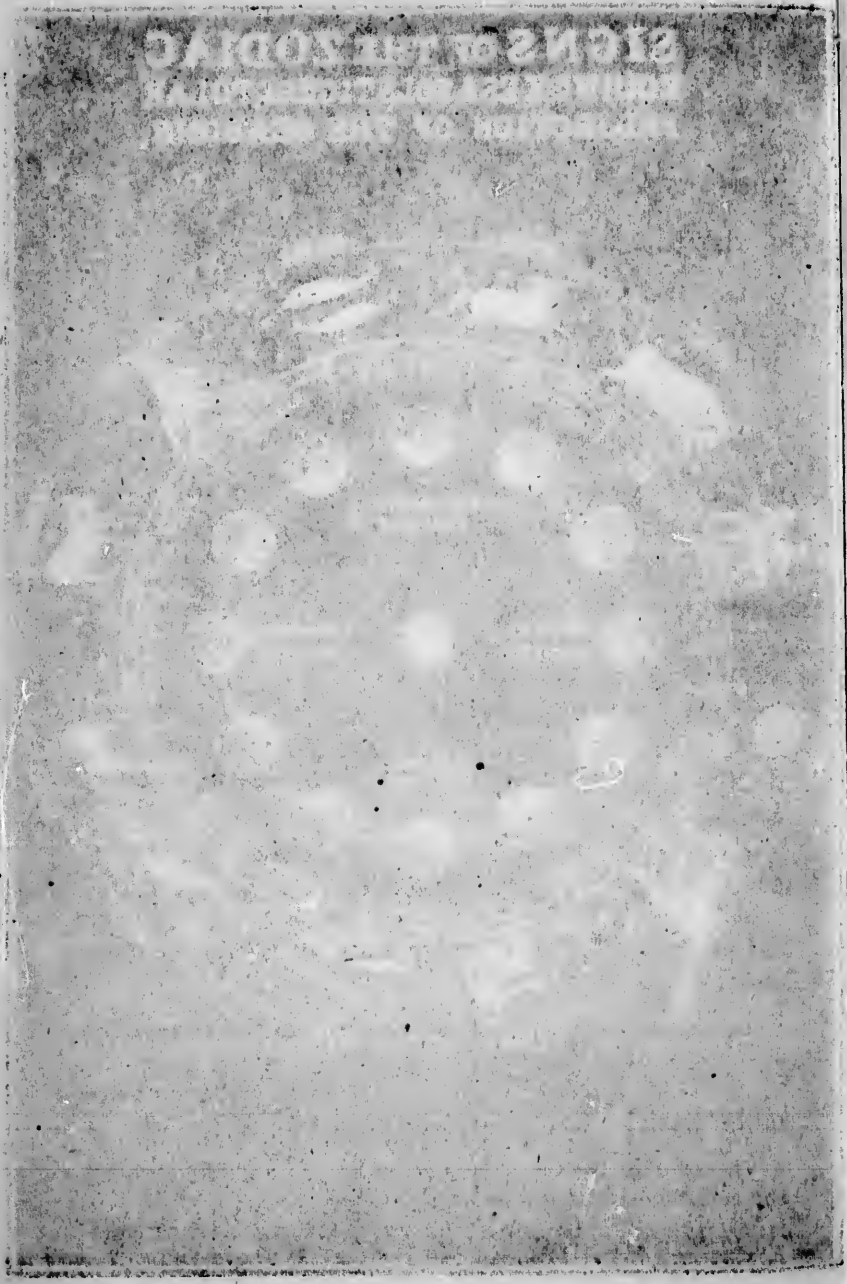
ECLIPTIC AND ZODIAC.

QUESTION. What is the ecliptic?

ANSWER. It is the plane of the earth's orbit, extended to the heavens, and intersects the equinoctial at an angle of 23½ degrees, (23° 28′).

[*Note.*—It is the apparent path of the sun around the heavens once a year, caused by the real motion of the earth around the sun.]


SIGNS OF THE ZODIAC



Q. What is the equinoctial?

A. It is a great circle in the heavens directly over the equator.

[*Note.*—It is the plane of the earth's equator extended to the heavens.]

Q. What is the zodiac?

A. It is a circular belt in the heavens, 16 degrees wide; 8 degrees on each side of the ecliptic.

Q. What great circle is in the middle of the zodiac?

A. The ecliptic or orbit of the earth.

Q. How is the zodiac divided?

A. It is divided into twelve equal parts, called signs or constellations of the zodiac.

Q. How is the ecliptic divided?

A. It is divided into twelve equal parts, called signs.

Q. How is each sign divided?

A. Each sign is divided into 30 degrees, each degree into 60 minutes, each minute into 60 seconds, &c.

Q. What are the names of the constellations of the zodiac and the signs of the ecliptic?

A. Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, and Pisces.

Q. Do the constellations of the zodiac, and the signs of the ecliptic, occupy the same places in the heavens?

A. They do not: the signs in the ecliptic have fallen back of the constellations about 31 degrees.

Q. Did the constellations of the zodiac and the signs of the ecliptic ever correspond?

A. They corresponded to each other about 22 centuries ago.

Q. What is the cause of the falling back of the signs of the ecliptic among the constellations?

A. It is caused by the retrograde motion of the equinoxes.

[*Note.*—This variation is caused by the pole of the earth varying a little every year This motion of the pole of the earth is similar to that sometimes shown by a top, as it spins around on the point. The stem of the top will have a circular motion, describing a cone with the apex or top down. This circular motion of the pole of the earth is very slow, varying only 50″ every year, and requires 25,868 years to complete a revolution—which is called the Platonic or great year. The pole of the earth is increasing its distance from the north star, and in 12,900 years it will be about 47° from it; and when the north star is on the meridian, it will be in the zenith of the northern part of the United States: but in 25,800 years the pole will have made a complete revolution—so that it will point again to the north star.]

Q. Upon what does the length of the year depend?

A. It depends upon the revolution of the earth from one equinox to the same again.

Q. Does the earth revolve around the sun in exactly the same time that it moves from one equinox to the same equinox again?

A. It moves from either equinox to the same again seventeen miuutes sooner, than around the sun.

LESSON XII.

QUESTION. Does the sun appear to move in the heavens among the stars?

ANSWER. It has an apparent motion in the ecliptic, eastward around the heavens, during the year.

Q. How is this appearance caused, as the sun is in the centre, and does not move?

A. It is caused by the earth's moving around the sun.

Q. If the earth is in the sign Aries, where does the sun appear to be?

A. It appears to be in the opposite sign, *Libra*.

Q. As the earth moves around in the ecliptic, where does the sun appear to move?

A. It appears to move in the opposite part of the heavens from west to east.

Q. Which sign does the sun enter, when the north pole leans exactly towards the sun?

A. Cancer. (21st June.)

Q. Which sign does the earth enter at this time?

A. Capricornus.

Q. Which signs does the sun enter, when the north pole leans sideways to the sun?

A. Aries and Libra.

Q. Which sign does the sun enter, when the north pole leans exactly from the sun?

A. Capricornus. (22d December.)

Q. Which are the equinoctial signs?

A. Aries, 21st of March—Libra, 23d of September.

Q. Which are the solstitial signs?

A. Cancer, 21st of June—Capricornus, 22d of December.

LESSON XIII.

QUESTION. How are the signs of the ecliptic divided?

ANSWER. They are divided into four divisions, corresponding to the seasons.

Q. Which are the spring signs?

A. Aries, Taurus, Gemini.

Q. Which are the summer signs?

A. Cancer, Leo, Virgo.

Q. Which are the autumnal signs?

A. Libra, Scorpio, Sagittarius.

Q. Which are the winter signs?

A. Capricornus, Aquarius, Pisces.

Q. In what time do the equinoxes fall back through the whole circle of the Zodiac?

A. 25,800 years.

Q. What is this time called?

A. The Platonic, or great year.

Q. How is this motion caused?

A. It is caused by a slow annual change in the direction of the earth's axis.

Q. What is longitude in the heavens?

A. It is the distance from the first degree of the sign Aries, reckoned eastward on the ecliptic, the whole circumference of the heavens.

Q. When the sun enters Aries, what is its longitude?

A. It has no longitude.

Q. What is the longitude of the earth at that time?

A. 180 degrees.

Q. When the sun enters Cancer, what is its longitude?

A. 90 degrees—the earth's longitude at the same time 270 degrees.

Q. When the sun enters Libra, what is its longitude?

A. 180 degrees—the earth's longitude 0 degrees.

Q. When the sun enters Capricornus, what is the longitude?

A. 270 degrees—the earth's longitude at the same time 90 degrees.

LESSON XIV.

MERCURY.

QUESTION. Which planet is the smallest and nearest the sun?

ANSWER. Mercury.

Q. What is the diameter of Mercury?

A. 3,200 miles.

Q. What is the distance from the sun?

A. 37 millions of miles.

Q. What is its magnitude, compared with the earth?

A. It is $\frac{1}{17}$ of the earth's magnitude.

Q. In what time does it revolve on its axis, or perform its daily revolution?

A. In about 24 hours. (24 hours 5 minutes.)

Q. In what time does it revolve around the sun.

A. In about 88 days. (87d. 23h. 14m. 33s.)

Q. How fast does it move in its orbit around the sun?

A. It moves 112,000 miles an hour.

Q. What is the light or heat at Mercury compared with that of the earth?

A. It is about seven times as great.

Q. What is elongation?

A. It is the apparent distance of any planet from the sun.

Q. What is the greatest elongation of Mercury?

A. 30 degrees; which may be either east or west of the sun.

Q. Why is Mercury never seen in superior conjunction?

A. Because it is so much involved in the light of the sun.

Q. Does Mercury experience any change of seasons?

A. It does not, because its axis is perpendicular to its orbit. This causes the sun to be continually vertical at the equator.

LESSON XV.

VENUS.

QUESTION. What planet is next to Mercury?

ANSWER. Venus.

Q. What is the diameter of Venus?

A. 7,700 miles.

Q. What is its distance from the sun?

A. 68 millions of miles.

Q. What is its magnitude compared with the earth?

A. It is about $\frac{9}{10}$ of the earth's magnitude.

Q. In what time does it revolve on its axis?

A. In about 23½ hours. (23h. 21m.)

Q. In what time does it revolve around the sun?

A. In 224 days. (224d. 16h. 41m. 27s.)

Q. How fast does it move in its orbit around the sun?

A. It moves 75,000 miles an hour.

Q. What is the comparative light or heat at Venus?

A. It is about double that of the earth.

Q. What is the greatest elongation of Venus?

A. About 47 degrees.

Q. When is Venus a morning star?

A. When it is west of the sun, and rises before it.

Q. When is it an evening star?

A. When it is east of the sun, and sets after it.

Q. How long is Venus a morning or an evening star, alternately?

A. About 290 days.

Q. Why is Venus a morning or an evening star 66 days longer than the time of its revolution around the sun?

A. Because the earth is moving around the sun the same way.

LESSON XVI.

Question. How much is the axis of Venus inclined to that of its orbit?

Answer. 75 degrees.

Q. When the north pole of Venus inclines directly towards the sun, how many degrees will the axis point above the sun?

A. Only 15 degrees.

Q. How wide a torrid Zone does this make?

A. 150 degrees—75 degrees on each side of the equator.

Q. The tropics are within how many degrees of the poles?

A. Within 15 degrees.

Q. The polar circles are within how many degrees of the equator?

A. 15 degrees.

Q. What is the diameter of the polar circles?

A. 150 degrees.

Q. Has Venus any variation of seasons?

A. She has two summers and two winters at the equator, and a summer and winter at each of the poles, during the year.

Q. How does Venus appear, when viewed with a telescope?

A. She exhibits phases similar to those of the moon.

Q. What is the transit of a heavenly body?

A. It is its passage across the meridian.

Q. What is meant by the transit of Mercury and Venus?

A. It is their passage across the sun's disc.

Q. What is the disc of the sun or a planet?

A. It is the circular illuminated surface visible to us.

Q. How do Mercury and Venus appear when passing across the sun's disc?

A. They appear like black spots moving across the sun.

Q. What proof have we that Mercury and Venus are not luminous bodies?

A. When viewed with the telescope they appear horned like the moon.

Q. On which side of the sun does the transit begin?

A. On the east side, and terminates on the west side.

Q. What apparent motions have the planets?

A. Three; direct, stationery, and retrograde.

Q. When does a planet's motion appear to be direct?

A. When it appears to move from west to east among the stars.

Q. When is a planet's motion said to be stationery?

A. When it is moving directly towards or from the earth.

Q. When is a planet's motion said to be retrograde?

A. When it appears to move backwards, or from east to west among the stars.

LESSON XVII.

EARTH, DEFINITIONS, ETC.

Question. What is the shape of the earth?

Answer. It is round like a globe or ball, a little flattened at the poles.

Q. How do we know the earth to be round?

A. 1st. Navigators have sailed round it, by a continued westerly or easterly course. 2d. The

top-mast of a ship coming in from the sea, always appears first. 3d. The earth's shadow upon the moon, in a lunar eclipse, is circular.

Q. In what manner do the inhabitants stand upon the earth?

A. They stand with their feet directed towards the centre of the earth.

Q. What do you understand by the terms upward and downward?

A. Upwards is from the centre of the earth, downward is towards the centre of the earth.

Q. What keeps the inhabitants, etc., upon the surface of the earth?

A. The attraction of the earth.

Q. What is the axis of the earth?

A. It is the straight line round which it performs its daily revolution.

Q. What are the poles of the earth?

A. They are the extremities of its axis.

Q. How are the circles of the globes divided?

A. They are divided into great and small.

Q. What is a great circle?

A. It is a circle whose plane divides the earth into two equal parts, called hemispheres.

Q. What are the poles of a great circle?

A. They are two opposite points in the heavens, equally distant from all parts of the circumference.

[*Note.*—The poles of the horizon are the *Zenith* and *Nadir*. The poles of the equator, or equinoctial, are those points where the earth's axis, if produced each way, would meet the heavens. The north star is situated in one of these points.]

Q. What is a small circle?

A. It is a circle whose plane divides the earth into two unequal parts.

Q. Which are the great circles used in Astronomy?

A. Equator, Meridian, Horizon, Ecliptic, and Equinoctial.

[*Note.*—The equator divides the earth into northern and southern hemispheres—the meridian divides it into eastern and western hemispheres, and the horizon divides it into upper and lower hemispheres.]

Q. Which are the small circles, used in Astronomy?

A. The tropics and polar circles, parallels of latitudes, altitude and declination.

[*Note.*—Parallels of latitude are small circles parallel to the equator—parallels of altitude are small circles parallel to the horizon—parallels of declination are small circles, on the celestial globe, parallel to the equinoctial, and correspond to parallels of latitude on the earth; or if parallels of latitude on the earth should be extended to the heavens, they would then become parallels of declination.]

Q. What is the equator?

A. It is a great circle, whose plane divides the earth into northern and southern hemispheres.

Q. To what is the plane of the equator perpendicular?

A. It is perpendicular to the earth's axis, and equi-distant from the poles.

Q. What is the meridian of a place on the earth?

A. It is a great circle passing through the place, and the poles of the earth.

Q. Into what does the plane of the meridian divide the earth?

A. Into eastern and western hemispheres.

Q. What is the latitude of a place on the earth?

A. It is its distance from the equator, north or south.

Q. On what is it measured?

A. On a meridian,

Q. How far is latitude reckoned?

A. Ninety degrees.

Q. What places have ninety degrees of latitude?

A. The poles.

Q. What are the tropics?

A. They are two small circles parallel to the equator at a distance of 23½ degrees north and south of it.

Q. What are the polar circles?

A. They are two small circles one around each pole, at a distance of 23½ degrees from it.

LESSON XVIII.

QUESTION. Which is the first meridian?

ANSWER. It is the meridian from which longitude is reckoned.

Q. Which meridian is generally used in this country as the first meridian?

A. The meridian of London.

Q. What is the longitude of a place on the earth?

A. It is its distance east or west of the first meridian.

Q. How far is terrestrial longitude reckoned?

A. It is reckoned 180 degrees, or half round the earth.

Q. What is the horizon?

A. It is a great circle which separates the visible heavens from the invisible.

Q. What are the cardinal points of the horizon?

A. North, East, South, and West.

Q. How many horizons are there?

A. Two; the visible and the rational.

Q. What is the visible or sensible horizon?

A. It is that circle where the earth and sky appear to meet.

Q. What is the rational horizon?

A. It is a great circle, parallel to the visible horizon, whose plane passes through the centre of the earth.

Q. Into what does it divide the earth?

A. Into upper and lower hemispheres.

Q. Is the rational horizon above or below the visible horizon.

A. It is below the visible horizon.

LESSON XIX.

QUESTION. Do all places on the earth have the same horizon?

ANSWER. They do not; if we change our place on the earth, the horizon changes.

Q. What are the cardinal points in the heavens or the poles of the horizon?

A. The zenith and nadir.

Q. What is the zenith?

A. It is that point in the heavens directly over our heads.

Q. Do all places have the same zenith?

A. They do not; every place has a different zenith.

Q. What is the nadir?

A. It is that point in the heavens which is opposite to the zenith or directly under our feet.

Q. Are the zenith and nadir fixed points in the heavens?

A. They are not; they make a complete revolution in the heavens every 24 hours.

Q. What is the altitude of a heavenly body?

A. It is its height or distance from the horizon.

Q. What is the polar distance of a heavenly body?

A. It is its distance from the pole.

Q. Who are the antipodes?

A. Those who live on directly opposite sides of the earth.

Q. Who are the antœci?

A. Those who live in equal latitude, on directly opposite sides of the equator.

Q. Who are the periœci?

A. Those who live in equal latitude, on opposite sides of the pole.

LESSON XX.

EARTH AND SEASONS.

QUESTION. What is the shape of the earth?

ANSWER. It is round like a globe or ball, a little flattened at the poles.

Q. What is its position in the solar system?

A. It is the third planet from the sun.

Q. What is the mean diameter of the earth?

A. 7,192 miles. (Equatorial diameter 7,926 miles; polar diameter 7,899 miles.)

Q. How much greater is the equatorial than the polar diameter?

A. About 27 miles.

Q. What causes the equatorial diameter to be greater than the polar?

A. It is caused by the revolution of the earth on its axis.

[As the greater portion of the surface of the earth is covered with water; and as the earth revolves on its axis; the water

recedes from the poles towards the equator, until its tendency to run back towards the poles, just balances the effects of the centrifugal force. This causes the equatorial diameter to be greater than the polar. If the earth should stop revolving on its axis, the water at the equator would settle away towards the poles, until they had assumed the form of a globe as near as possible. Thus large portions of land in the torrid zone, which are now covered by the ocean, would be left dry, and new continents and islands would be formed.]

Q. What is the mean distance of the earth from the sun?

A. About 95,000,000 miles.

[The mean distance of a planet, is the distance it would always be from the sun, if its orbit should be reduced to a true circle.]

Q. What is the specific gravity of the earth?

A. It is 5½ times the weight of water. (5.48.)

Q. In what time does the earth revolve on its axis, or perform its diurnal revolution?

A. In 24 hours. (In 23 hours 56 minutes; as seen from the stars.

Q. Which way does it revolve?

A. From west to east.

Q. What causes day and night?

A. The light of the sun causes day, and the shade of the earth causes night.

Q. How great a portion of the earth is continually in the light of the sun?

A. One half; the other half being in the shade of the earth.

Q. What does the revolution of the earth upon its axis cause?

A. The succession of day and night.

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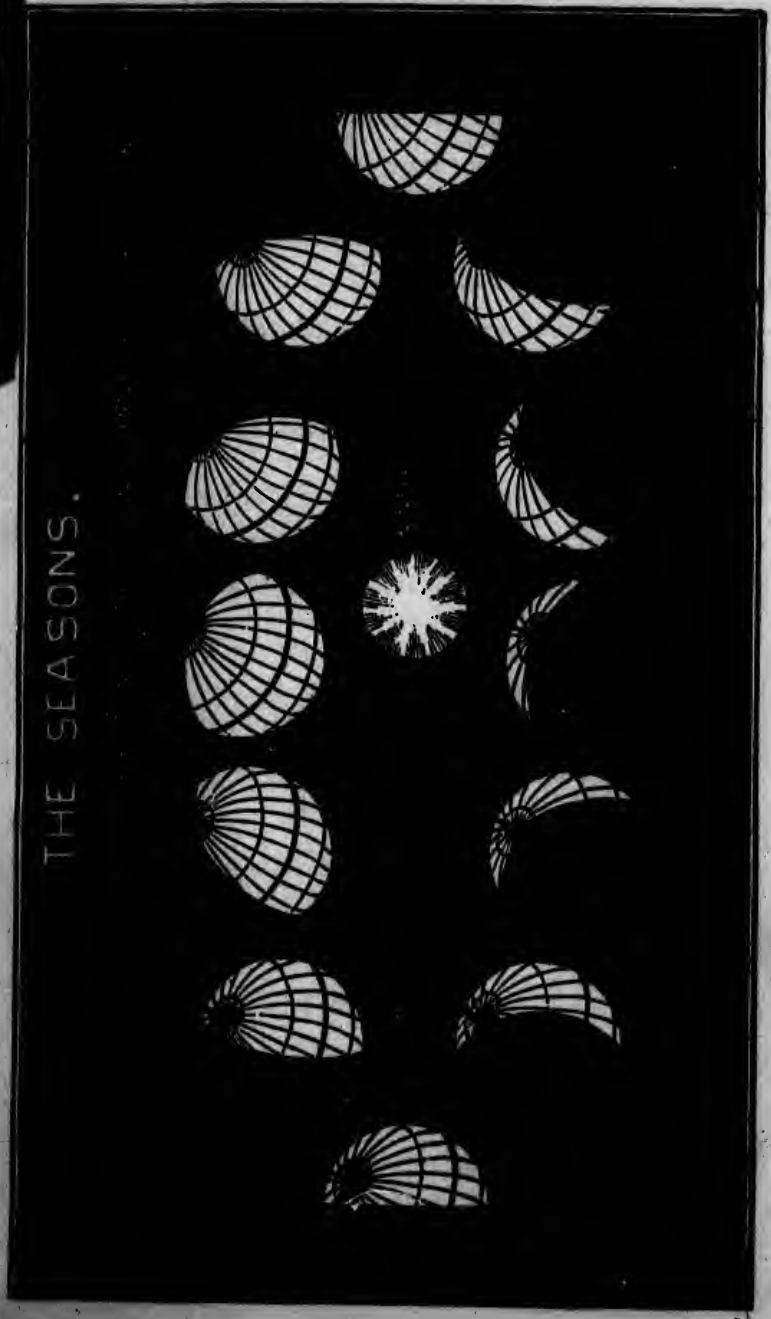

LESSON XXI.

QUESTION. As the earth turns upon its axis, what effect is produced?

ANSWER. The sun is continually rising to places in the west, and continually setting to places in the east.

Q. In what time does the earth revolve around the sun, or perform its annual revolution?

A. In 365 days 6 hours.

Q. How fast does it move in its orbit around the sun?

A. 68,000 miles an hour.

Q. How are the changes of the seasons caused?

A. They are caused by the earth's axis, being inclined to that of its orbit, and its revolution around the sun.

Q. How many degrees is the earth's axis inclined to that of its orbit?

A. Twent-three degrees and a half. (23° 28′.)

Q. Is the direction of the earth's axis changed during the year?

A. Its change is so slight that it may be considered as pointing to the same place in the heavens.

Q. When does the north pole lean directly towards the sun?

A. On the 21st of June, called the summer solstice.

Q. How many degrees does it lean towards the sun?

A. 23½ degrees; and the sun is vertical 23½ degrees north of the equator.

Q. What seasons does this produce?

A. Summer in the northern hemisphere, and winter in the southern.

Q. When does the north pole lean directly from the sun?

A. On the 22d of December, called the winter solstice.

Q. When the north pole leans from the sun, what are the seasons?

A. Winter in the northern hemisphere, and summer in the southern.

LESSON XXII.

QUESTION. What are the cardinal points of the ecliptic?

ANSWER. The equinoctial and solstitial points.

Q. At what points of the ecliptic is the earth at the time of the solstices?

A. At the solstitial points.

Q. Through how much of its orbit does the earth pass, in moving from one solstitial point to the other?

A. One half of its orbit, or from one side of the sun to the other.

Q. What are those two points called, half way between the solstitial points?

A. The equinoctial points.

Q. Why are they so called?

A. Because, when the earth is in these points, the sun is vertical at the equator, and the days and nights are every where equal.

Q. When is the sun at the vernal equinox?

A. On the 21st of March.

Q. When is it at the autumnal equinox?

A. On the 23d of September.

Q. Which way does the pole lean when the earth is at the equinoctial points?

A. It leans sideways to the sun, the sun being vertical at the equator.

Q. When the north pole leans towards the sun, why is summer produced in the northern hemisphere?

A. Because the rays of the sun strike it more directly than in winter; consequently, they are not spread over so great a surface.

Q. When the north pole leans from the sun, why is winter produced in the northern hemisphere?

A. Because the rays of the sun strike it so obliquely, that they spread over a greater surface than in summer.

Q. At what points do the ecliptic and equinoctial intersect each other?

A. At the equinoctial points.

Q. At what angle do the ecliptic and equinoctial intersect each other?

A. 23½ degrees.

Q. How far are the solstitial points from the equinoctial points?

A. Ninety degrees.

LESSON XXIII.

MARS.

QUESTION. WHAT is Mars?

ANSWER. Mars is the fourth planet from the sun.

Q. What can you say of its size?

A. It is the smallest, except Mercury and the asteroids.

Q. What is its diameter?

A. 4,189 miles.

Q. What is its distance from the sun?

A. 142 millions of miles.

Q. What is its magnitude?

A. It is about one seventh of the size of the earth.

Q. In what time does it revolve on its axis?

A. In about 24½ hours. (24h. 39m. 22s.)

Q. In what time does it revolve around the sun?

A. In one year, 321 days.

Q. How fast does it move in its orbit?

A. 55,000 miles an hour.

Q. How many degrees does the axis of Mars lean towards its orbit?

A. About 30 degrees, (30° 18′.)

Q. Does Mars have any change of seasons?

A. The seasons are similar to those of the earth, but nearly twice as long.

Q. Why are they longer?

A. Because Mars is nearly two of our years in revolving around the sun.

Q. What is the appearance of Mars when seen with the naked eye?

A. It appears of a red fiery color.

LESSON XXIV.

QUESTION. How does Mars appear, when viewed with a telescope?

ANSWER. Outlines of apparent continents and seas are distinctly seen.

Q. What appearance have the continents?

A. They have a ruddy color, rising probably from the nature of the soil.

Q. Of what color are the seas?

A. They appear of a greenish color, caused no doubt by contrast with the red color of the continents.

Q. Does Mars present different phases?

A. It sometimes appears gibbous.

Q. When does a planet appear gibbous?

A. When we can see more than half, but not the whole, of the illuminated surface.

Q. Does Mars ever appear horned like the moon?

A. It does not, because it does not pass between us and the sun.

Q. What other appearances does Mars exhibit when viewed with a telescope?

A. Bright spots are seen alternately at the poles.

Q. When do these spots appear?

A. When it is winter, or continual night at the poles.

Q. What is supposed to be the cause of these spots?

A. Snow and ice, which has accumulated at these poles during the winter.

Q. Do these spots continue through the year?

A. They entirely disappear as the summer advances upon the poles.

Q. What amount of light and heat has Mars?

A. It has about half as much as the earth.

LESSON XXV.

JUPITER.

QUESTION. What is Jupiter?

ANSWER. Jupiter is the largest planet in the solar system.

Q. How many times larger is Jupiter than the earth?

A. It is 1,280 times greater.

Q. How far is Jupiter from the sun?

A. 485 millions of miles.

Q. What is its diameter?

A. 87,000 miles.

Q. Which diameter is the greater, the polar or equatorial?

A. The equatorial diameter is 6,000 miles greater than the polar.

Q. What causes the equatorial diameter so much to exceed the polar?

A. The quick rotation of the planet on its axis.

Q. In what time does it revolve upon its axis?

A. In about 10 hours. (9h. 55m. 50s.)

Q. In what time does it revolve around the sun?

A. In eleven years, 314 days.

Q. How fast does it move in its orbit around the sun?

A. 30,000 miles an hour.

Q. How many moons has Jupiter?

A. Four.

Q. Has Jupiter any change of seasons?

A. It has no change of seasons.

Q. Why do its seasons not change?

A. Because its axis is nearly perpendicular to the plane of its orbit, which causes the sun to be always vertical at the equator.

Q. How does Jupiter appear when viewed with a telescope?

A. Light and dark belts appear to surround it.

Q. What are the light belts?

A. They are supposed to be clouds, which are thrown into parallel lines by the quick rotation of the planet, upon its axis.

Q. What are the dark belts?

A. They are probably the body of the planet, seen between the clouds.

Q. Do these belts always appear the same?

A. They change frequently, and sometimes the clouds break to pieces.

Q. What is the velocity of its equatorial parts, in turning on its axis?

A. 25,000 miles an hour.

Q. What amount of light and heat has Jupiter?

A. It has 27 times less than the earth.

LESSON XXVI.

SATURN.

QUESTION. What is Saturn?

ANSWER. It is the largest planet except Jupiter.

Q. What is its magnitude compared with the earth?

A. It is about 1,000 times larger.

Q. What is the diameter of Saturn?

A. 79,000 miles.

Q. What is its distance from the sun?

A. 890 millions of miles.

Q. In what time does it revolve on its axis?

A. In about 10½ hours. (10h. 29m. 16s.)

Q. In what time does it revolve around the sun?

A. In 29 years and a half. (29y. 167d.)

Q. How fast does it move in its orbit around the sun?

A. 22,000 miles an hour.

Q. Is there any change of seasons at Saturn?

A. There is; but it is very slow, as it takes

nearly thirty of our years, to complete a year at Saturn.

Q. How much does the axis of Saturn lean towards its orbit?

A. About 30 degrees. (28° 40′.)

Q. How long is its day and night alternately at the poles?

A. About 15 of our years.

Q. What has Saturn which surrounds it?

A. Two large rings of solid matter like the planet.

Q. What is their position around the planet?

A. They are directly over the equator.

LESSON XXVII.

QUESTION. Do these rings revolve with the planet?

ANSWER. They do, and in nearly the same time as the planet.

Q. Are these rings connected with the planet, or separate?

A. They are separate from the planet, and from each other.

Q. What is the distance from the planet to the inner ring?

A. 19,000 miles.

Q. How wide is the inner ring?

A. 17,000 miles.

Q. How wide is the space between the rings?

A. About 1,800 miles.

Q. What is the width of the outer ring.

A. 10,000 miles.

Q. How thick are these rings?

A. About 100 miles. (Some say, 1,000 miles.)

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Q. Are these rings uniform?

A. They are rough and uneven.

Q. How many satellites or moons has Saturn?

A. Eight.

Q. What is the position of their orbits?

A. Their orbits, excepting one, are directly over the rings.

Q. Does the sun always shine on the same side of the rings?

A. It shines upon each side alternately for fifteen years.

Q. What amount of light and heat has Saturn?

A. It has 90 times less than the earth.

Q. What appearance has the disc of Saturn?

A. It has dark belts similar to those of Jupiter.

LESSON XXVIII.

HERSCHEL, OR URANUS.

QUESTION. When was Herschel or Uranus discovered?

ANSWER. In 1781.

Q. By whom?

A. By Sir William Herschel, who was a celebrated English Astronomer.

Q. In what part of the solar system is Herschel situated?

A. It is the fifteenth planet from the sun, and next to the farthest discovered.

Q. What is its magnitude?

A. It is 80 times larger than the earth.

Q. What is its distance from the sun?

A. 1800 millions of miles.

Q. In what time does it revolve on its axis?

A. It is not certainly known. [It has been stated at 1 day 18 hours, but there seems to be no proof of it.—*Professor Nichol.*]

Q. In what time does it revolve around the sun?

A. In about 84 years. (84y. 6d.)

Q. How fast does it move in its orbit around the sun?

A. 15,000 miles an hour.

Q. How will the light and heat at Herschel compare with the same at the earth?

A. They are 368 times less.

Q. How many moons has Herschel?

A. Six moons were seen by Sir Wm. Herschel, but only three have been seen by other astronomers.

Q. In what direction do these moons move in their orbits?

A. They move from east to west, contrary to the motions of all the other planets, both primary and secondary.

LESSON XXIX.

LEVERRIER, OR NEPTUNE.

QUESTION. When was Neptune discovered?

ANSWER. In 1846, by Dr. Galle, of Berlin.

Q. Who published the elements of this planet, and directed astronomers to the point in the heavens where it might be discovered?

A. Leverrier, a celebrated French mathematician.

Q. How near the point, where he directed astronomers to look, was it found?

A. Within one degree.

Q. What is the diameter of this planet?

A. It is about 35,000 miles.

Q. What is its magnitude?

A. It is about 80 times larger than the earth.

Q. What is its distance from the sun?

A. About 2,850 millions of miles.

Q. In what time does it revolve on its axis?

A. It is not known.

Q. In what time does it revolve around the sun?

A. In about 166 years.

Q. How many moons has Leverrier?

A. One; and another is supposed to have been seen.

Q. What amount of light and heat has this planet?

A. About 900 times less than that of the earth.

Q. Are the primary planets inhabited?

A. They appear to be inhabitable.

[*Note.*—The presence of clouds indicating both air and water; the regular succession of the seasons, as well as day and night; the suitable amount of light received from the sun; the accompaniment of moons; the specific gravity of bodies at their surface; all seem to indicate that the primary planets are suitable residences for living beings. The only objection to this view is, the difference in the amount of heat received from the sun, supposing it to be according to the inverse ratio of the squares of their distances from the sun. But we see from the difference of temperature on the earth, at the base and summit of high mountains, that the actual heat depends much upon the modifying circumstances, as well as upon the direct rays of the sun. And we have reason to suppose that the temperature of the other planets does not differ much from that of the earth.

For instance the temperature of Mars, as indicated by the melting of its snow, and that of Jupiter and Saturn, as indicated by the amount of vapor in their atmosphere, appear to be similar to that of the earth. Mercury and Venus are protected from the direct rays of the sun by dense clouds. Causes unknown to us may, and probably do, modify the temperature of all the planets in a greater or less degree, sufficiently so, for purposes of animal life.]

LESSON XXX.

MOON.

QUESTION. What is the moon?

ANSWER. The moon is a secondary planet, revolving around the earth.

Q. Is the moon larger or smaller than the earth?

A. It is 49 times less than the earth.

Q. What is the diameter of the moon?

A. 2,180 miles.

Q. What is the specific gravity of the moon?

A. It is 3½ times the weight of water, (3.37.)

Q. What is its mean distance from the earth?

A. Two hundred and forty thousand miles.

Q. In what time does the moon revolve around the earth?

A. In about 27½ days, (27d. 7h. 43m. 11s. 5.)

Q. In what time does the moon revolve upon its axis?

A. In about 27½ days, or in the same time that it revolves around the earth.

Q. What is the result of the moon's revolving upon its axis and around the earth in the same time?

A. The same side of the moon is always presented to the earth.

Q. Have we ever seen the opposite side of the moon?

A. We have not.

Q. What causes the moon always to present the same side to the earth?

A. It is supposed that one side of the moon is more dense than the other, consequently the centre of gravity is not in the centre of the moon.

Q. What is a lunation, or lunar month?

A. It is the time from one new moon, to another.

Q. What is the length of a lunation?

A. About 29½ days. (29d. 12h. 44m.)

Q. Why is a lunation longer than the time it takes the moon to revolve around the earth?

A. Because the earth is revolving around the sun at the same time.

LESSON XXXI.

QUESTION. What is the length of the days or nights at the moon?

ANSWER. About 15 of our days.

Q. Which way does the moon revolve around the earth?

A. From west to east.

Q. If the moon revolves from west to east, what causes it to rise in the east?

A. It is caused by the earth's revolving on its axis the same way.

Q. Does the moon rise the same hour every evening?

A. It rises about 50 minutes later every day.

Q. What is the cause of its rising 50 minutes later every day?

A. It is caused by the moon's daily progress in its orbit from west to east.

Q. What causes the phases of the moon, from new moon to new moon again?

A. It is caused by the moon's revolving around the earth.

Q. When is it new moon?

A. When the moon is between the earth and sun, and the dark side is presented to us.

Q. When is it full moon?

A. When the moon is upon the opposite side of the

earth from the sun, and the illuminated side is presented to us.

Q. How much greater is the light of the sun than that of the full moon?

A. 800,000 times greater.

Q. When are the sun and moon in quadrature?

A. When they are ninety degrees distant from each other.

Q. How much of the illuminated side of the moon is visible to us when it is in quadrature?

A. One-half.

Q. How much larger is the sun than the moon?

A. 70 millions of times greater.

Q. Why does the moon appear as large as the sun?

A. Because it is four hundred times nearer to us than the sun.

LESSON XXXII.

QUESTION. Has the moon an atmosphere?

ANSWER. Very little, if any.

Q. What is the appearance of the moon, when viewed with a telescope?

A. It appears covered with light and dark spots of various shapes.

Q. What is the cause of this appearance?

A. It is caused by the mountains, plains and valleys in the moon.

Q. What are the light spots?

A. Mountains and elevated land.

Q. What are the dark spots?

A. Plains, valleys, etc.

Q. Has the moon any ocean, seas, or large bodies of water?

A. Not upon the side towards the earth.

Q. If you were living upon this side of the moon, what would be the appearance of the earth?

A. The earth would appear like a large stationary moon.

Q. How much larger than the moon appears to us?

A. Thirteen times greater.

Q. In what time would the heavenly bodies appear to revolve around the moon?

A. The stars would appear to revolve in 27½ days, the sun in 29½ days.

Q. What is the shape of the moon's orbit?

A. Elliptical, or one diameter greater than the other.

Q. What is apogee?

A. It is the point in the orbit of the moon, farthest from the earth.

Q. What is perigee?

A. It is the point in the orbit of the moon, nearest to the earth.

Q. When is the moon in apogee?

A. When it is at its greatest distance from the earth.

Q. When is the moon in perigee?

A. When it is nearest to the earth.

Q. Has the moon any change of seasons?

A. None, except those changes which take place every lunar month.

Q. What is the harvest moon?

A. When the moon is full in September and October, it rises only a few minutes later for several successive evenings, and thus affords light for col-

lecting the harvest; it is therefore called the harvest moon.

Q. What is the cause of the harvest moon?

A. It is caused by the moon's orbit being very oblique to the horizon.

Q. Is the moon inhabited?

A. The want of air and water render it uninhabitable by beings like ourselves.

PHYSICAL CONSTITUTION OF THE MOON.

In viewing the moon with the naked eye, her disc appears diversified with dark and bright spots, which, on being examined with a powerful telescope, are discovered to be mountains and valleys. The whole surface of the moon is covered with these spots, which is evident from the fact that the line of separation between the illuminated and dark hemispheres, is, at all times, extremely ragged and uneven.

The mountains on, or near, this line, cast behind them long black shadows, like those of the mountains of the *Earth*, when the sun is rising or setting. The moon is a much more mountainous body than the earth, and the mountains are vastly higher, compared with its size, than those of the earth. One of the mountains, (*named Tycho,*) situated in the south-east part of the Moon, is apparently a volcanic crater 50 miles in diameter, and 16,000 feet deep, with a central mountain rising to the height of 5,000 feet. The height of ten of the principal mountains, according to the recent measurement of Mædler, is from 3½ to 4⅔ miles. The mountains of the moon do not run in ranges, like those of the earth; but are single peaks scattered over nearly the whole surface of the moon, and are generally of a circular form, shaped like a cup. These facts substantially pro[illegible] the mountains of the moon to be of volcanic origin; and, in some of the principal ones, decisive marks of volcanic stratification [illegible]ng from successive deposits of ejected matter, may be distinctly traced with powerful telescopes.

The moon contains no large bodies of water, such as oceans, seas, etc.; at least, not upon the side visible to us. If there are any, they must be upon the opposite side of the moon, which is never presented to us. The moon also has very little, if any, atmosphere; at least, none of sufficient density to refract the rays of light in their passage through it: owing to these two circumstances, there are no clouds floating around the moon; if there were any, they would at times be visible to us, but none have been observed. It presents the same appearance that it did 2,000 years ago; no trace of vegetation or change of seasons has been observed; every

thing appears solid, desolate, and u... fo... support of animal or vegetable life.

Whether the materials, of which the moon is composed, are of the same nature as the earth, we have no means of knowing. It has, however, been ascertained that its density, compared with the density of the earth, is .615, or a little more than one-half; consequently, the materials of which the moon is composed, are about one-half as heavy as the same bulk of the earth.

There being little or no atmosphere about the moon, the heavens, during its daytime, have the appearance of night to the inhabitants of the moon, when they turn their backs to the sun; and the stars then appear, as bright to them, as they do in the night to us; for it is entirely on account of the light which our atmosphere reflects, that the heavens appear luminous about us in the daytime. If our atmosphere were removed, only that part of the heavens would be light, in which the sun is situated; and, if we turned our backs to the sun, the heavens would appear as dark as night.

The light which the full moon affords us is very small, when compared with the light of the sun; it being 300,000 times less. It has also been demonstrated, that the light reflected by the moon produces no heat; as its rays, when collected by the aid of the most powerful glasses, have not been perceived to produce the slightest effect upon the thermometer.

IS THE MOON INHABITED?

From the physicial constitution of the moon, it is evident that the moon is not inhabited; at least, by beings constituted like ourselves.

The moon having little, or no atmosphere, we could not exist upon its surface for a single hour, even though provided with the other necessary means for our existence: nevertheless, this is not positive evidence that the moon is not inhabited. The same power that called the moon into existence, could as easily constitute beings fitted to inhabit its surface, and enjoy an existence, which is productive of as much happiness to them, as ours is to us.

It may be very properly asked—if the moon is not a habitable body, for what purpose was it created? This is a question which is more easily asked than answered. We might as well ask, why the greater portion of the surface of the earth is not land instead of water? why is Africa a sandy desert, or why are the polar regions unfitted for the habitation of man?

According to geologists, the *Earth* was, for a long period of time, in a state unfit for animal life, and that it has undergone many successive changes, extending through a long period of time, before it was fitted for the abode of mankind. It may be that the moon is in a transition state, and has not arrived at a state suitable for animal life.

We know but few of the numerous purposes the moon *may serve*, in the economy of nature. We do know that it exerts a powerful influence in raising the *tides*. Its mild beams tend to dispel the gloom of night, especially in the dreary winter of the polar regions. It furnishes the navigators at sea, the most certain means known, of determining their longitude. In the earliest periods of the world, its changes furnished the *ancients* with a convenient mode of reckoning time. It is also thought by many to exert an important influence upon the animal and vegetable kingdom; but this is denied by others equally entitled to credit.

LESSON XXXI.

ECLIPSES.

QUESTION. What is an eclipse?

ANSWER. It is the interception of the sun's rays by some opaque body.

Q. How are eclipses divided, with respect to the body eclipsed?

A. Into two kinds; solar and lunar.

Q. What is a solar eclipse?

A. It is an eclipse of the sun.

Q. What is the cause of an eclipse of the sun?

A. It is caused by the moon's passing between the earth and sun, and casting its shadow upon the earth.

Q. When must an eclipse of the sun take place?

A. It can happen only at new moon.

Q. What is a lunar eclipse?

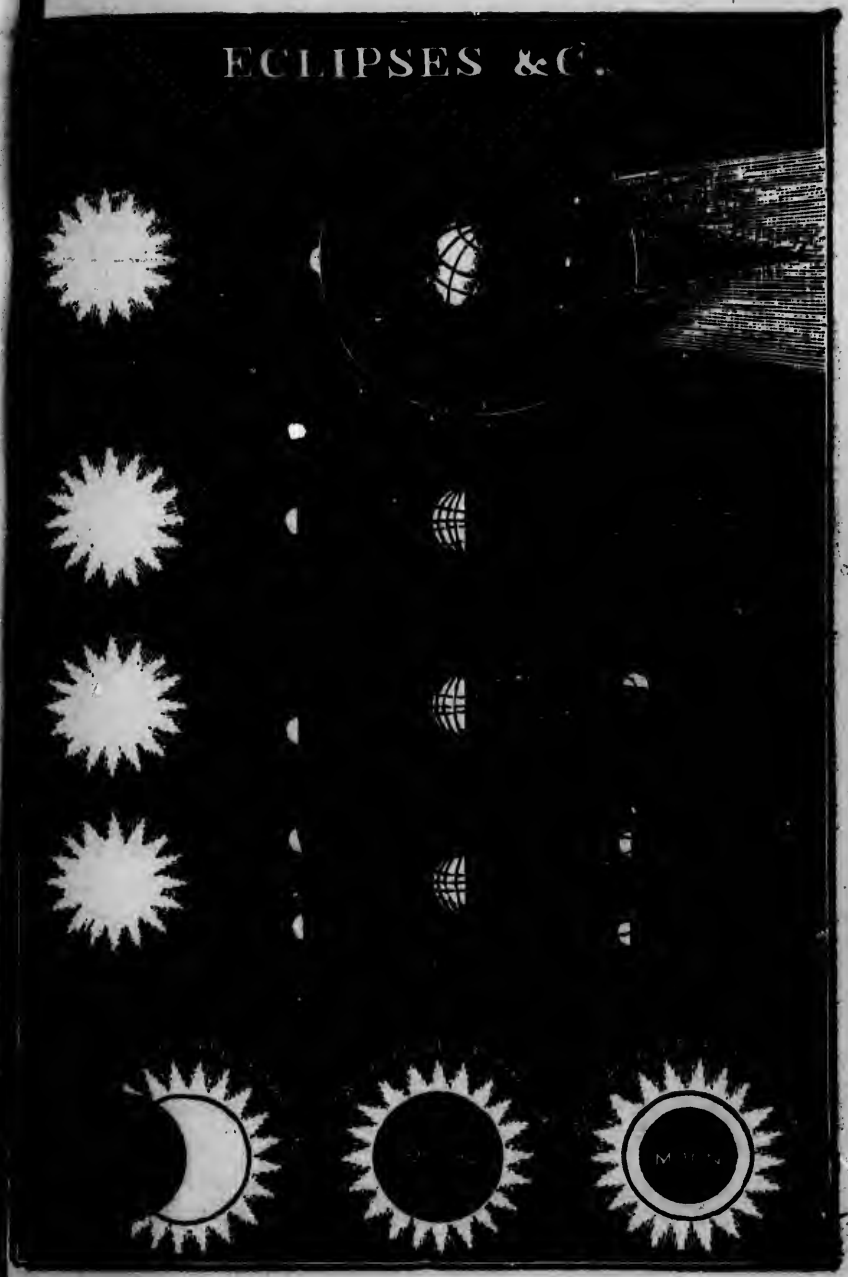
A. It is an eclipse of the moon.

Q. What causes an eclipse of the moon?

A. It is caused by the moon's passing through the earth's shadow.

Q. When must an eclipse of the moon take place?

A. It can happen only at full moon.


ECLIPSES &C.

Q. How are eclipses divided, with respect to the amount eclipsed?

A. Into total and partial.

Q. What is a total eclipse?

A. It is an eclipse of the whole of the sun or moon.

Q. What is a partial eclipse?

A. It is an eclipse of only a part of the sun or moon.

Q. What is an annular eclipse?

A. It is an eclipse of the central part of the sun, when the moon is so far from the earth, that the sun can be seen like a bright ring around it.

Q. Do we have an eclipse of the sun at every new moon?

A. We do not.

Q. Why do we not have an eclipse of the sun at every new moon?

A. Because at new moon, the moon is generally too high, or too low, for its shadow to fall upon the earth.

Q. Do we have an eclipse of the moon at every full moon?

A. We do not; at full moon, the moon generally passes above or below the earth's shadow.

Q. What is the length of the earth's shadow?

A. About 600,000 miles. [NOTE.—This is the mean or average length.]

Q. What is the length of the moon's shadow?

A. About 234,000 miles. [NOTE.—This is the mean, or average length.]

Q. What is a digit?

A. It is the twelfth part of the apparent diameter of the sun or moon's disc.

Q. What is the greatest number of eclipses that can take place in a year?

A. Seven; five of the sun, and two of the moon.

Q. What is the least number of eclipses that can take place in a year?

A. Two: and both must be of the sun.

LESSON XXXIV.

THE MOON'S NODES.

QUESTION. What are nodes?

ANSWER. They are two opposite points, where the orbit of the moon, or any other planet, intersects the plane of the earth's orbit, or ecliptic.

Q. What angle does the moon's orbit make with the plane of the earth's orbit, or ecliptic.

A. About 5½ degrees. (5° 8′ 48″.)

Q. What part of the moon's orbit is above, or north of the plane of the earth's orbit?

A. One-half; the other half being below, or south, of the earth's orbit.

Q. What is the ascending node?

A. It is that point, where the moon passes the plane of the earth's orbit from south to north.

Q. What is the descending node?

A. It is that point, where the moon passes the plane of the earth's orbit from north to south.

Q. Do the nodes change their position, as regards a fixed point in the heavens?

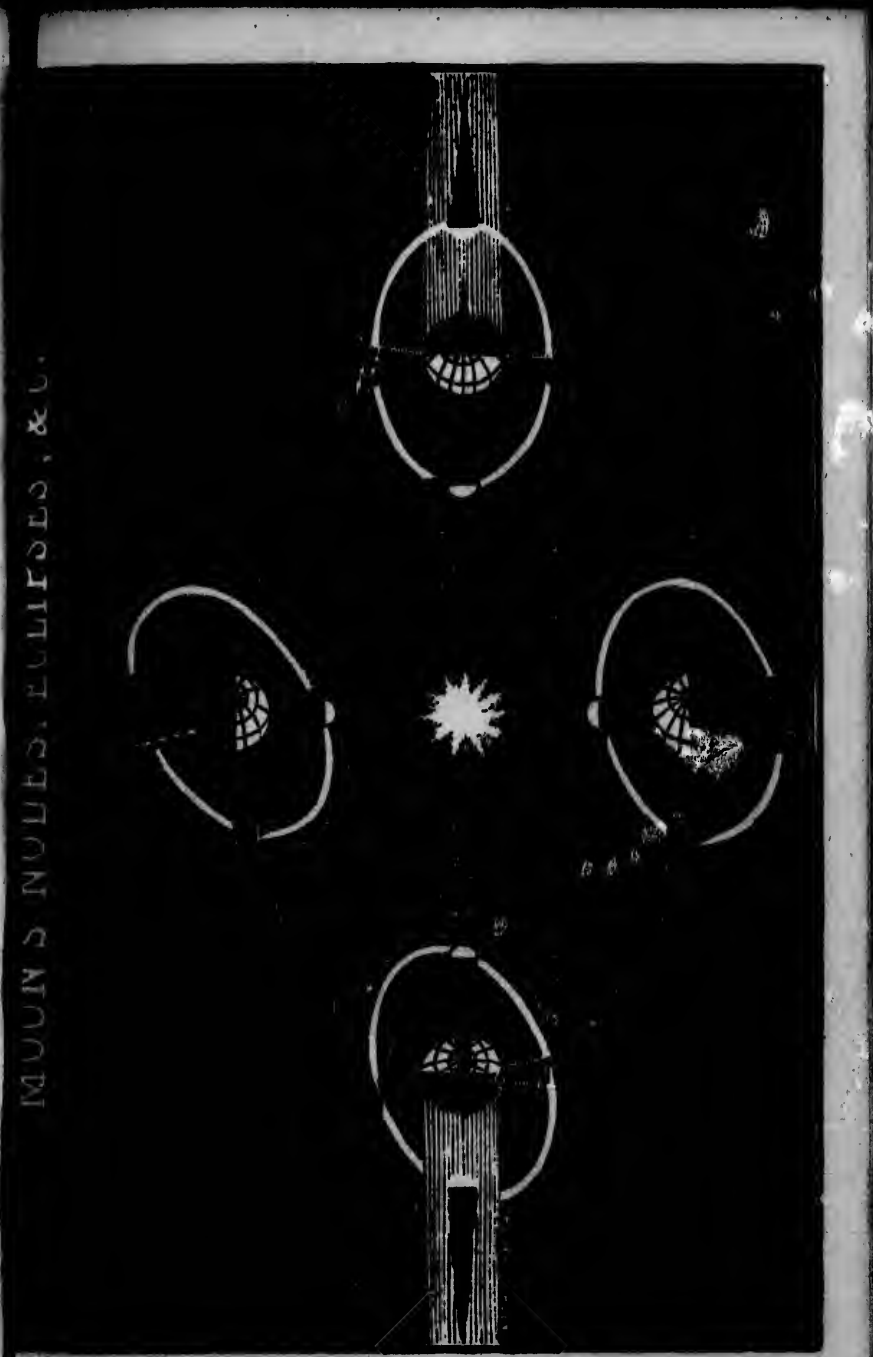
A. They have a retrograde motion of about 19 degrees in a year.

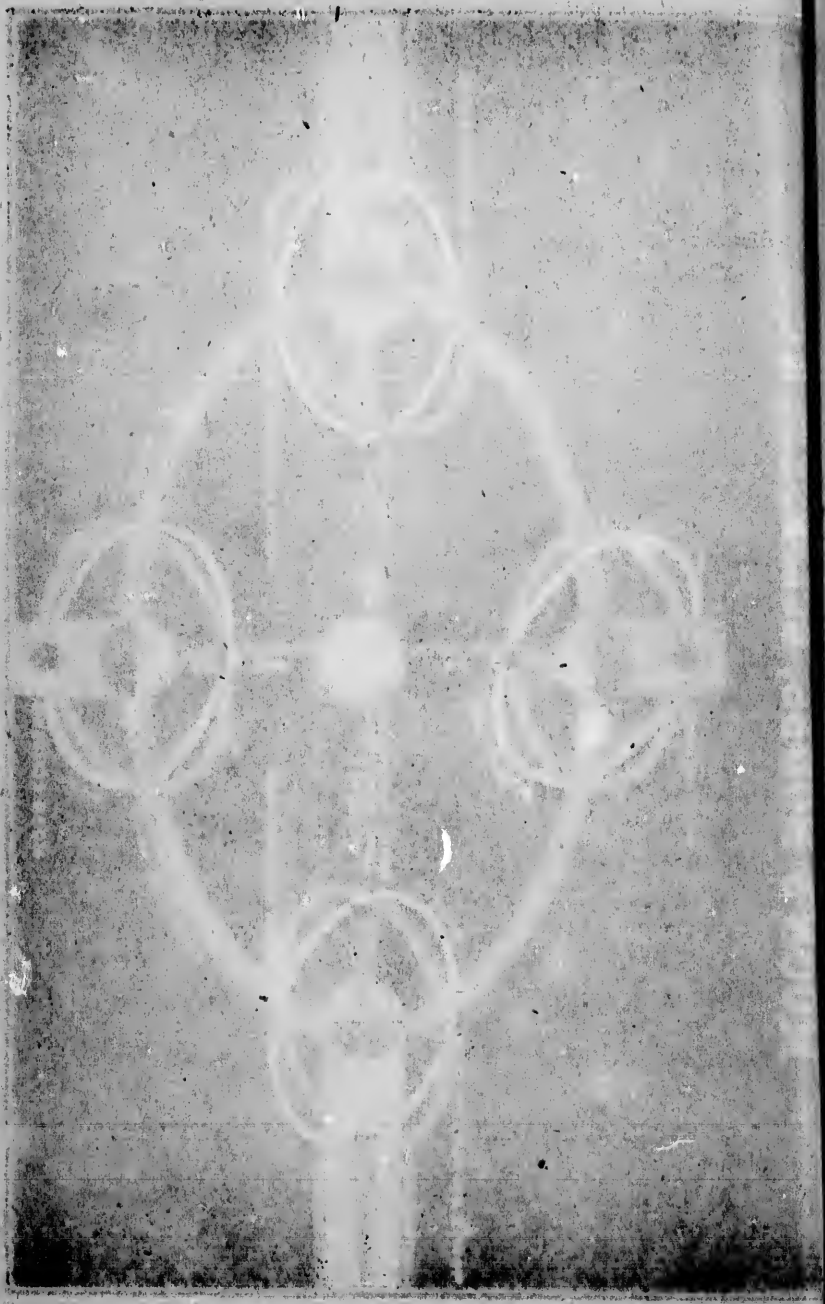
Q. When is the moon in north latitude in the heavens?

A. When it is north of the earth's orbit, or ecliptic.

Q. When is the moon in south latitude in the heavens?

A. When it is south of the earth's orbit, or ecliptic.


MOON'S NODES, ECLIPSES, &C.



Q. What is the greatest latitude of the moon?

A. 5¼ degrees north or south of the earth's orbit or ecliptic.

Q. What is the greatest declination of the moon, or its distance north or south of the equinoctial, or equator?

A. About 28½ degrees.

LESSON XXXV.

QUESTION. How near one of the nodes must the moon be, at new moon to cause an eclipse of the sun?

ANSWER. Within seventeen degrees. (16° 59′.)

Q. How near one of the nodes must the moon be, at full moon, to cause an eclipse of the moon?

A. About 12 degrees. (11° 25′ 4″.)

Q. If the moon is exactly in one of her nodes at new or full moon, what kind of an eclipse will it cause?

A. It will cause a great eclipse of the sun, or moon.

Q. What is the extent of the solar ecliptic limit, in which an eclipse of the sun can take place?

A. Thirty-four degrees, seventeen degrees on each side of either node.

Q. What is the extent of the lunar ecliptic limit, in which an eclipse of the moon can take place?

A. Twenty-four degrees; twelve on each side of either node.

HELIOCENTRIC AND GEOCENTRIC LATITUDE AND LONGITUDE.

Q. What is the Heliocentric latitude and longitude of a planet?

A. It is its latitude and longitude, as seen from the sun.

Q. What is the Geocentric latitude and longitude of a planet?

A. It is its latitude and longitude, as seen from the earth.

Q. Does a planet, seen from the earth, appear to have the same longitude as it would have, if seen from the sun at the same time?

A. It does not, unless the earth is between the sun and planet.

LESSON XXXVI.

TIDES.

QUESTION. What motion have the earth and moon, besides revolving around the sun?

ANSWER. They revolve around their common centre of gravity.

Q. In what part of a straight line, joining their centres, is the centre of gravity situated?

A. About 3,200 miles from the centre of the earth.

Q. What effect has the centrifugal force upon the water on the opposite side of the earth from the moon?

A. It causes it to recede from the centre of gravity, and to rise on that part of the earth.

Q. What effect has this upon the shape of the earth?

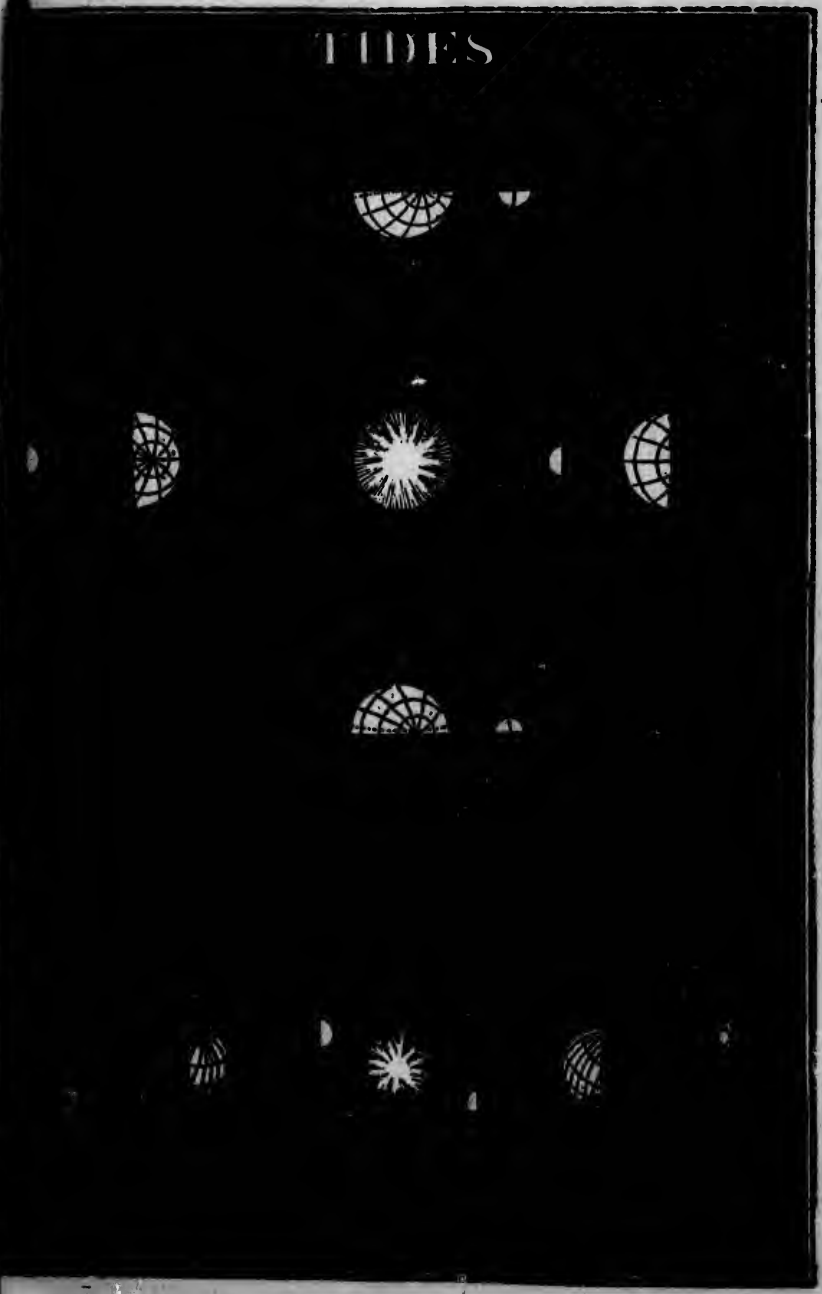
A. Its diameter is lengthened in the line of the moon's attraction, and shortened at right angles to it.

Q. What tends to increase this oval shape of the earth?

A. The inequality of the attraction of the moon, at the different sides of the earth.

[The water upon the side of the earth nearest to the moon, is more attracted than the centre of the earth; the water, upon the opposite side, is less attracted.]

Q. What effect does the turning of the earth from west to east, on its axis, produce on these elevations or tide waves?


TIDES

A. It causes these elevations, or tide waves, to pass from east to west around the earth.

Q. What is tide?

A. It is the rising and falling of the waters of the ocean.

Q. How are the tides divided, with respect to the rising and falling of the water?

A. Into flood and ebb.

Q. What is flood tide?

A. It is the rising of the water.

Q. What term designates the greatest elevation of the flood tide?

A. High water.

Q. What is ebb tide?

A. It is the falling of the water.

Q. How often do flood and ebb tide occur?

A. Twice in about 25 hours.

Q. Do the tides rise at the same hour every day?

A. They rise about an hour later each day.

Q. Why do the tides rise later?

A. Because the moon passes the meridian about an hour later each day.

Q. What causes the moon to be later at the meridian?

A. It is caused by its daily progress eastward in its orbit.

Q. Does the attraction of the sun produce an effect similar to that of the moon?

A. It tends to raise a tide two-fifths as high.

Q. When the sun and moon are on the same or opposite sides of the earth, what is the effect of their attractive forces?

A. They raise a tide equal to the sum of their separate tides.

Q. When they are in quadrature, what is the effect of their counteracting forces?

A. They raise a tide equal to the difference of their tides.

LESSON XXXVII.

QUESTION. How are tides divided, with respect to their comparative height?

ANSWER. Into spring, and neap.

Q. What is spring tide?

A. It is the greatest flood and ebb tide.

Q. What is neap tide?

A. It is the least flood and ebb tide.

Q. What proportion do these tides bear to each other?

A. The neap tide is about three-sevenths as great as the spring tide.

Q. When do spring tides occur?

A. Twice in each lunar month, at new and full moon.

Q. When do neap tides occur?

A. Twice in each lunar month, at the quarters.

Q. What effect have the continents upon the tide waves, when passing round the earth?

A. They subject them to great irregularities.

Q. Which side of the continents have the highest tides; the eastern, or the western?

A. The eastern side.

Q. Does the water remain permanently higher on the east, than on the west, side of the continents?

A. The gulf of Mexico is 20 feet higher than the Pacific Ocean, and the Red Sea is 30 feet higher than the Mediterranean.

Q. Where the tide wave is least obstructed, as in the Pacific Ocean, how much behind the moon is it?

A. It is two or three hours behind it.

Q. How long after the moon passes the meridian, is it high water at New York?

A. About 8½ hours.

Q. If the earth were uniformly covered with water, how high would the tide rise?

A. Not more than two or three feet. (The tide at the small islands in the Pacific Ocean is usually less.)

Q. What produces the greatest effect in causing high tides?

A. The shape of the land, and the position of the shores.

Q. Where are the highest tides in the world?

A. In the Bay of Fundy.

Q. What, besides the position of the shores, tends to raise a high tide at that place?

A. The meeting of the tide wave from the North Atlantic Ocean, with the main one from the South Atlantic.

Q. How high are the average spring tides at Cumberland, near the head of the Bay of Fundy?

A. About 71 feet.

Q. How high are they at Boston?

A. About 11 feet.

Q. At New York?

A. About 5 feet.

Q. At Charleston, South Carolina?

A. About 6 feet.

Q. When do we have the highest tides in the northern hemisphere?

A. During the day time in summer, and during the night in the winter.

LESSON XXXVIII.

ORBITS OF THE PLANETS AND COMETS.

QUESTION. What is the orbit of a primary planet?

ANSWER. It is the path in which it revolves around the sun.

Q. What is the orbit of a secondary planet?

A. It is the path in which it revolves around its primary.

Q. What is the form of the orbits of all the planets?

A. Elliptical, or longer one way than the other.

Q. Are all the orbits elliptical in the same proportion?

A. They are not; some are more elongated than others.

Q. What is the position of the orbits of all the planets?

A. They extend from west to east in the heavens.

Q. Do the planes of their orbits intersect the ecliptic, or orbit of the earth?

A. They do, at small angles.

Do they all intersect the plane of the earth's orbit at one point?

A. They do not; but intersect it at different points.

Q. Through what point does the plane of the orbit, of every primary planet and comet in the solar system, pass?

A. Through the centre of the sun.

Q. Are the planets at nearly the same distance from the sun?

A. They are not; but at very different distances.

Q. Are their orbits all contained within the zodiac?

A. They are, except those of a part of the asteroids.

Q. How wide is the zodiac?

A. Sixteen degrees wide; eight degrees on each side of the ecliptic.

Q. Do all the planets revolve around the sun in the same direction?

A. They do; from west to east.

Q. Do they all move with the same velocity?

A. The velocity decreases as the distance from the sun increases.

Q. Which planet moves in its orbit with the greatest velocity?

A. Mercury.

Q. Which moves with the least?

A. Leverrier, or Neptune.

Q. When does a planet have north latitude?

A. When it is above, or north, of the earth's orbit.

Q. When does a planet have south latitude?

A. When it is below, or south, of the earth's orbit.

LESSON XXXIX.

COMETS.

QUESTION. What are comets?

ANSWER. They are bodies which revolve around the sun in very elongated orbits.

Q. How are comets usually distinguished from the planet?

A. By a luminous train, or tail, on the opposite side from the sun.

Q. Is this luminous train always on the opposite side from the sun?

A. Not always; a few have been observed to have a different direction.

Q. Do comets ever appear without a luminous train?

A. Some are entirely destitute of any such appendage.

Q. What is the number of comets?

A. The number is not known; about 500 have been seen at different times.

Q. Are comets solid bodies like the planets?

A. They generally are not; although some have been observed to have a dense nucleus, or head.

Q. What is the nature of comets?

A. They are supposed to be gaseous matter, in the form of smoke, fog, or clouds.

Q. Do comets shine by their own, or by reflected light?

A. They shine by reflected light.

Q. Do they all, like the planets, revolve in the same direction around the sun?

A. They do not; they revolve in different directions.

Q. Are all their orbits within the zodiac?

A. They are not; their orbits are in all directions in the heavens.

Q. How do many of them move when first seen?

A. They appear to move in almost a direct line towards the sun.

Q. Does their velocity increase as they approach the sun?

A. It does; and, when near it, they move with immense velocity.

Q. How fast has a comet been known to move?

A. 880,000 miles an hour.

LESSON XL.

ATMOSPHERE.

QUESTION. What is air?

ANSWER. It is an elastic, invisible fluid, which surrounds the earth.

Q. Of what, besides air, is the atmosphere composed?

A. Of vapor, carbonic acid, and other gases.

Q. Is the atmosphere of the same density as we ascend from the earth?

A. It grows thinner or less dense.

Q. What is the estimated height of the atmosphere?

A. About forty-five miles.

Q. What is the pressure of the atmosphere upon the earth?

A. Nearly fifteen pounds to the square inch. (14.6.)

Q. What is the weight of air compared with water?

A. It is 816 times lighter than water.

Q. The pressure of the atmosphere is equal to the weight of a column of water, of what height?

A. Thirty-three feet.

Q. Of what is air composed?

A. Of oxygen and nitorgen gases.

Q. In what proportions?

A. Twenty parts of oxygen, to eighty parts of nitrogen.

LESSON XLI.

REFRACTION.

QUESTION. What is refraction?

A. It is the deviation of the rays of light from a straight line.

Q. What is astronomical refraction?

A. It is the deviation of the rays of light in their passage through the atmosphere.

Q. What is the cause of this refraction?

A. It is caused by the increase of the density of the atmosphere towards the earth.

Q. In what part of the heavens is the light of a body most refracted?

A. In the horizon.

Q. What effect does this refraction have upon the sun, at its rising and setting?

A. It makes the sun appear above the horizon, when it is actually below it.

Q. Does this affect the length of the day?

A. It makes the day from six to ten minutes longer, from sunrise to sunset.

Q. Is the light of a body refracted when it is in the zenith?

A. It is not.

Q. What is twilight?

A. It is that faint light, seen before the sun rises and after it sets.

Q. What is the cause of twilight?

A. It is caused by the atmosphere's reflecting the light of the sun.

Q. Twilight ceases when the sun is, how far below the horizon?

A. Eighteen degrees.

LESSON XLII.

PARALLAX.

QUESTION. What is parallax?

ANSWER. It is the difference between the apparent and true place of a heavenly body.

Q. What is the apparent place of a planet?

A. It is the place where it appears to be, when seen from the surface of the earth.

Q. What is the true place of a planet?

A. It is the place where it would appear to be, if

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seen from the centre of the earth, or centre of motion.

Q. Where is the parallax of a heavenly body the greatest?

A. At the horizon, and decreases to the zenith.

Q. How are parallaxes divided?

A. They are divided into two kinds; diurnal and annual parallax.

Q. What is diurnal parallax?

A. It is the apparent difference in the situation of a heavenly body, when seen in the zenith and horizon of two places, at the same time. (See parallax of Mars and Moon.)

Q. What is annual parallax?

A. It is the apparent difference in the situation of a star, as seen from the earth in opposite points of its orbit.

Q. Have the stars been observed to have any sensible parallax?

A. A few have been observed to have a small parallax of a part of a second. (NOTE.—No parallax has been discovered in more than 30 or 40 of them.)

Q. What is the cause of their having no appreciable parallax?

A. Because they are at such an immense distance from us.

Q. If the earth's orbit were a solid ring, how large would it appear when viewed from the nearest fixed star?

A. No larger than a lady's finger ring.

LESSON XLIII.

LIGHT AND HEAT.

QUESTION. What bodies produce light?

ANSWER. Luminous bodies.

Q. Is light a substance thrown off from a luminous body, or is it caused by a vibratory motion?

A. It is probably caused by the undulations of an extremely subtle fluid.

Q. In what direction are the rays of light thrown off from a luminous body?

A. In straight lines, and in all directions.

Q. With what velocity does light move?

A. About 192,000 miles a second. (192,500.)

Q. How is this amazing velocity ascertained?

A. By observing the eclipses of Jupiter's moons.

Q. In what proportion do the light and heat of the planets increase or decrease?

A. In inverse proportion to the squares of their distances from the sun.

Q. Which planet has the most light and heat, and which the least?

A. Mercury has the most, and Leverrier the least.

Q. If a board a foot square be placed one foot from a lighted candle, how many feet square would the shadow be upon the wall, nine feet from the candle?

A. Nine feet square, or eighty-one square feet.

Q. What amount of light and heat would fall upon the one foot and upon the 81 feet?

A. The same amount of light and heat would fall upon each.

LESSON XLIV.

TERRESTRIAL AND CELESTIAL GLOBES.

QUESTION. What is a globe?

ANSWER. A globe is a round body or sphere.

Q. How many kinds of globes are there used in Astronomy?

A. Two; terrestrial and celestial globes.

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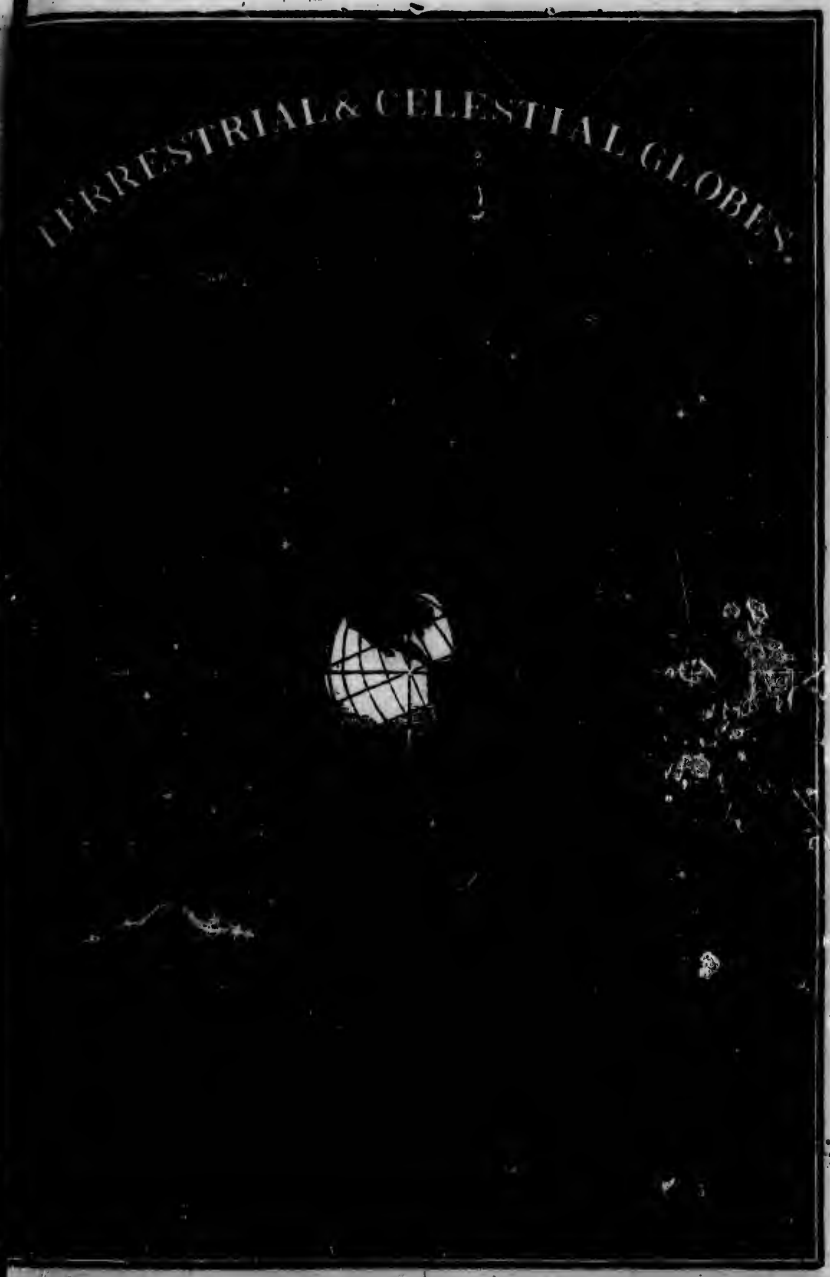

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Q. What does the terrestrial globe represent?

A. It represents the earth.

Q. What are drawn upon the surface of the terrestrial globe?

A. Continents, islands, mountains, oceans, seas, rivers, republics, kingdoms, empires, etc.

Q. What does the celestial globe represent?

A. It represents the heavens as seen from the earth.

Q. What are usually drawn on the celestial globe?

A. The constellations of stars, galaxy or milky way, and the figures of various animals and objects from which the constellations are named.

Q. What is a constellation?

A. It is a group of stars, to which is applied the name of some animal or object.

Q. What is the number of constellations?

A. Ninety-three.

Q. In viewing the terrestrial globe, where is the observer supposed to be placed?

A. On its surface.

Q. In viewing the celestial globe, where must the observer suppose himself to be placed?

A. In the centre, looking towards the heavens. (Inside, looking out.)

Q. What is the galaxy or milky way?

A. It is a luminous belt forming a complete circle in the heavens.

Q. Of what is the galaxy or milky way composed?

A. It is a vast number of stars, so far distant from us, and situated so nearly in the same direction, as to appear like a thin cloud.

Q. What is the position of the milky way in the heavens?

A. It extends from northeast to southwest through the whole circumference of the heavens.

Q. What are the celestial poles, or poles of the heavens?

A. They are the points where the earth's axis, if extended, would meet the heavens.

LESSON XLV.

QUESTION. What does the plane of the equator form, when extended to the heavens?

ANSWER. The equinoctial, or celestial equator.]

Q. At what angle do the ecliptic and equinoctial intersect each other?

A. At an angle of 23½ degrees. (23° 28′.)

Q. What does the plane of a meridian form, when extended to the heavens?

A. A celestial meridian, or circle of declination.

Q. What are measured on celestial meridians?

A. Declination and polar distance.

Q. What is the declination of a heavenly body?

A. It is its distance from the equinoctial, north or south.

Q. To what are the declination and polar distance always equal?

A. They are equal to 90 degrees, or a quarter of a circle.

Q. What is the right ascension of a heavenly body?

A. It is its distance east of the first point of Aries, measured on the equinoctial.

[Q. What angle expresses the right ascension?

A. The angle between the meridian passing through the body, and the one passing through the first point of Aries.]

Q. How far is right ascension reckoned?

A. 360 degrees, or quite round the heavens.

Q. What are circles of latitude on the celestial globe?

A. They are great circles which pass through the poles of the ecliptic, and cut its plane at right angles.

Q. What is the latitude of a heavenly body?

A. It is its distance north or south of the ecliptic, measured on a circle of celestial latitude.

Q. What is the longitude of a heavenly body?

A. It is its distance east of the first point of Aries, measured on the ecliptic.

[Q. What angle expresses the longitude?

A. The angle between the circle of latitude passing through the body, and the one passing through the first point of Aries.

Q. Where is this angle formed?

A. At the poles of the ecliptic, where the circles of latitude intersect one another.]

Q. How far is celestial longitude reckoned?

A. It is reckoned 360 degrees.

LESSON XLVI.

QUESTION. What is a vertical circle?

ANSWER. It is a great circle in the heavens, passing through the zenith and nadir, and cutting the horizon at right angles.

Q. What vertical circle is the meridian?

A. It is that vertical circle which passes through the north and south points of the horizon.

Q. Which is the prime vertical?

A. The vertical circle which passes through the east and west points of the horizon.

Q. What are measured on the vertical circles?

A. Altitude and zenith distance.

Q. What is the zenith distance of a heavenly body?

A. It is its distance from the zenith.

Q. To what are the altitude and zenith distance always equal?

A. They are equal to 90 degrees.

Q. What is the azimuth of a heavenly body?

A. It is its distance east or west of the meridian.

[Q. What angle expresses the azimuth?

A. The angle between the meridian and the vertical circle passing through the body.

Q. What is the amplitude of a heavenly body?

A. It is its distance north or south of the prime vertical.

Q. What angle expresses the amplitude.

A. The angle between the prime vertical, and the vertical circle passing through the body.

Q. Where are the angles expressing azimuth and amplitude formed.

A. At the zenith where the vertical circles intersect each other.

Q. On what circle are these angles measured?

A. On the horizon.

Q. To what are azimuth and amplitude always equal?

A. They are equal to 90 degrees.]

[The diagram can be used to illustrate azimuth, amplitude, altitude, and zenith distance, by supposing the ecliptic to represent the celestial horizon, and the circles of celestial latitude to represent vertical circles.]

LESSON XLVII.

THE FIXED STARS.

QUESTION. What are those stars called which always appear to be in the same situation with respect to each other?

ANSWER. They are called the fixed stars.

Q. What are the fixed stars supposed to be?

A. They are supposed to be suns like our own, with planets revolving around them.

Q. Are the stars luminous or opaque bodies?

A. They are luminous bodies. (Astronomers have no doubt on this point.)

Q. Are all the stars of the same magnitude as the sun?

A. They are not; some are larger, and others no doubt smaller than the sun.

[Astronomers, until recently, considered all the stars to be of about the same magnitude, and probably as large as the sun; and that the stars of the first magnitude owed their brilliancy to their being nearer to us; but it has been found that the brightest star (SIRIUS) in the whole heavens, and which was considered to be the nearest fixed star, is at a much greater distance than some of the smaller stars. This clearly demonstrates that they are of very unequal magnitude.]

Q. What is the distance of the nearest fixed star, α (Alpha) Centauri?

A. It is so far distant that a cannon ball going 500 miles an hour, would take four millions of years to reach it.

Q. What is the number of stars whose distance is imperfectly known to us?

A. About 35; seven of which have their distances determined with considerable certainty.

Q. Do all the stars remain of the same brilliancy?

A. They do not; some exhibit a periodical change in their light.

Q. What is supposed to be the cause of this change in their light?

A. The revolution on their axes is supposed to present alternately to us, sides of different brightness.

Q. What are those stars called, which appear to be surrounded by a thin atmosphere?

A. Nebulous stars.

Q. Do stars ever disappear, or new ones become visible?

A. Thirteen stars have disappeared, and ten new ones become visible, during the last century.

[There are now seven or eight well-attested cases of fixed stars suddenly glowing for a time with such brilliancy as to be visible in the day time, through the intensity of their light; then gradually fading away, and becoming entirely extinct. LAPLACE thinks that some great conflagrations, produced by extraordinary causes, have taken place on their surface.

Q. What is supposed to be the cause of their disappearance?

A. They have probably ceased to be luminous.

Q. How do astronomers account for the appearance of new stars?

A. Opaque bodies may have become luminous, or new suns may have been created.

LESSON XLVIII.

QUESTION. What do the milky way and the single stars that are visible to the naked eye, including our sun, constitute?

ANSWER. They constitute an immense cluster, or firmament, entirely distinct from the other clusters or nebulæ of the heavens.

Q. What is the shape of this great cluster or firmament?

A. It has the form of a wheel or burning-glass.

[The stars extend much farther in the direction of the plane of the milky way, than they do at right angles to it. SEE DIAGRAM.]

Q. What is the number of stars in our cluster?

A. They have been variously estimated, from 10 to 100 millions.

Q. By what term do some astronomers [illegible]nate our cluster or firmament?

A. They call it the universe.

[The term universe, was until recently, used to denote the whole creation of GOD, and was never used in the plural num-

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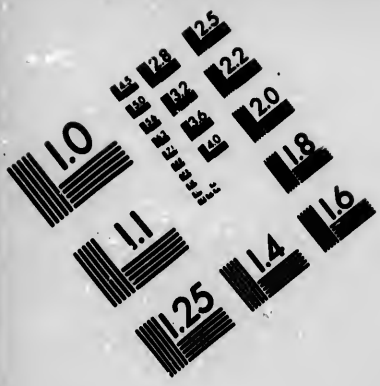

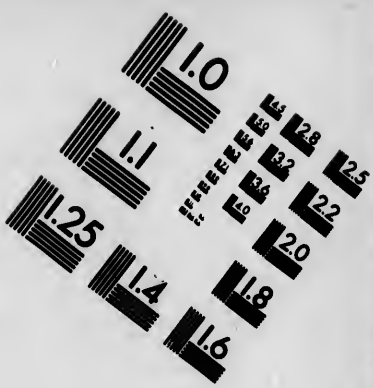

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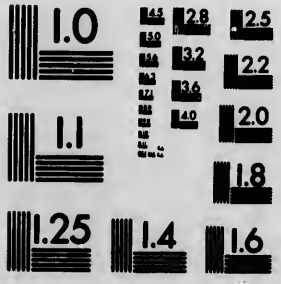

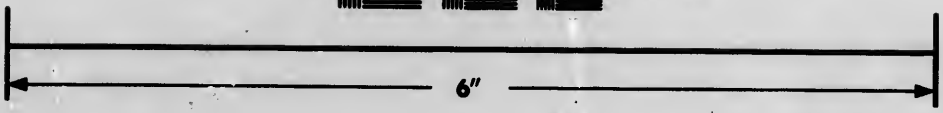

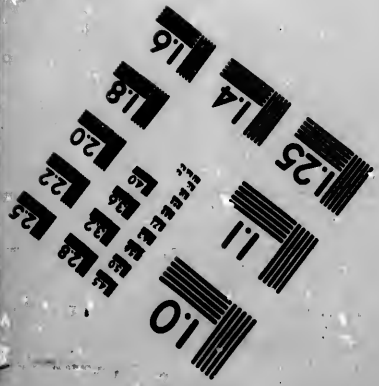

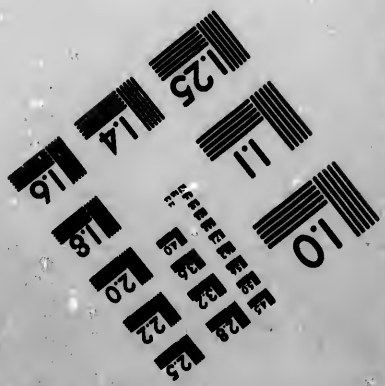

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BINARY OR DOUBLE STARS.

ber; but astronomers use the term to denote an immense firmament or cluster of stars, entirely distinct from other clusters—of which there are many thousands visible with the telescope—and are at an immense distance from each other. Hence, in speaking of these clusters, they call them universes. —PROF. MITCHELL.]

Q. Do the fixed stars have any apparent motion?

A. They do, but it is so slight as not to be easily detected.

Q. Around what, are all the stars in our cluster, including the sun, supposed to revolve?

A. Around the common centre of gravity of the cluster.

Q. What group of stars is thought to be near the centre of the cluster?

A. The Pleiades, or seven stars.—(DR. MAEDLER.)

Q. In what part of the cluster is the solar system situated?

A. It is comparatively near the centre.

Q. How far from us is the centre of the cluster supposed to be?

A. About 150 times the distance of the nearest fixed star.

[Light is about 8 minutes in coming from the sun; about 3½ years in coming from the nearest fixed star, α Centauri; about 500 years in coming from the supposed centre of the cluster; and about 5,000 years in coming from the most remote stars in the cluster.]

Q. How long will it take the sun to revolve around this centre of gravity?

A. About twelve millions of years.

Q. What other motion have some of the stars, besides around the centre of the cluster?

A. Multiple stars, consisting of two or more, revolve likewise around their common centre of gravity.

Q. What is the number of these multiple stars?

A. About 6,000 have been observed.

Q. Do these stars appear double to the naked eye?

A. They do not; the most, require a good telescope to separate them.

Q. When multiple stars consist of but two, what are they usually called?

A. Double stars, or binary systems.

LESSON XLIX.

NEBULÆ.

QUESTION. What appearance has a nebula?

ANSWER. A nebula appears like a spot of pale light seen in the heavens.

Q. Of what are the nebulæ composed?

A. The most of them are great clusters of stars, so far distant as to appear like a thin cloud.

Q. Are there many of them?

A. About 6,000 have been discovered.

[*Note.*—Their number is probably much greater; perhaps infinite.]

Q. What is the distance of these nebulæ?

A. Some of them are said to be so far distant, that light, travelling 192 thousand miles a second, would not reach us in less than 30 millions of years.—[PROF. MITCHELL.]

Q. Are they visible to the naked eye?

A. Only a few are seen without a telescope.

Q. How large do they appear when viewed with a telescope?

A. Some of them appear as large as one-tenth of the disc of the moon.

Q. Are these nebulæ seen in all parts of the heavens?

A. They are, although they are more numerous in a narrow zone, circumscribing the heavens, at right angles to the milky way.

Q. Into how many classes may nebulæ be divided?

A. Into five classes; viz., resolved nebulæ, resolvable nebulæ, stellar nebulæ, irresolvable and planetary nebulæ.

Q. What are resolved nebulæ?

A. They are those, which have been discovered with the telescope to be clusters of stars.

Q. What are resolvable nebulæ?

A. They are those, which are considered to be composed of stars, but are so far distant that the telescopes have not as yet resolved them.

Q. What are stellar nebulae?

A. They are those of an oval or round shape, increasing in density towards the centre.

[*Note.*—They sometimes present the appearance of having a dim star in the centre.]

Q. What are irresolvable nebulæ?

A. They are those, which are considered to be luminous matter in an atmospheric state, condensing into solid bodies like the sun and planets.

Q. What are the planetary nebulæ?

A. They are those, which resemble the disc of a planet, and are considered to be in an uncondensed state.

Q. Are all nebulæ beyond our cluster?

A. They are, except the milky way, and nebulous stars.

Q. By what general term do astronomers designate each nebula or cluster?

A. They call each nebula a UNIVERSE, or FIRMAMENT.

Q. What can you say of the great nebula in the GREYHOUNDS?

A. It resembles our cluster, or firmament of stars.

Q. What can you say of the great nebula in ORION?

A. This nebula was considered to be luminous matter in an uncondensed state; but it has lately been discovered to be stars by Lord Rosse, with his powerful telescope.

Note.—This nebula is visible to the naked eye.

Q. What is the probable cause of many of the nebulæ appearing elliptical or elongated? (SEE DIAGRAM.)

A. It is probably caused by the edge of the nebula being turned more or less towards us.

PROBLEMS

PERFORMED WITH THE TERRESTRIAL GLOBE.

PROBLEM I.—*To find the Latitude of any given place.*

RULE.—Bring the given place to the graduated side of the brass meridian, and the degree on the brass meridian over the place is the latitude, which is either north or south.

Q. What is the latitude of New York?

A. About 41 degrees north.

Q. What places have no latitude?

A. All places on the equator.

Q. Find the latitude of the following places:—

London,	Philadelphia,	Boston,	Washington,
Edinburgh,	Rome,	Dublin,	Amsterdam,
Moscow,	Stockholm,	Quito,	Mexico,
Algiers,	Astoria,	Cape of Good Hope,	Halifax,
Norfolk,	Aleppo,	Athens,	Ispahan,
Madras,	Madrid,	Cape Horn,	Cairo,
Prague,	Dantzic,	Teneriffe,	Lisbon,
Tripoli,	Paris,	Lima,	Vienna.

PROBLEM 2.—*To find the Longitude of any given place.*

RULE.—Bring the given place to the brass meridian, and the degree on the equator under the brass meridian, is the longitude.

[*Note.*—Longitude is reckoned from the meridian of Greenwich, 180 degrees east and west.]

Q. What is the longitude of New York?

A. 74 degrees west.

Q. What is the longitude of Pekin?

A. 116 degrees east.

Q. Find the longitude of the following places:—

Washington,	Hartford,	Sandwich Islands,	Gibraltar,
Quebec,	Rhodes,	Calcutta.	Constantinople
Canton,	Havana,	Jerusalem,	Nankin,
Pekin,	St. Petersburgh,	Venice,	Berlin,
Astoria,	Cape Horn,	New Orleans,	Rio Janeiro.

PROBLEM 3.—*To find any place whose latitude and longitude are given.*

RULE.—Bring the given longitude to the brass meridian, and under the given latitude is the place required.

Q. What place is situated in seventy-four degrees west longitude, and forty-one north latitude?

A. New York.

Q. What places have the following latitudes and longitudes?

Lat. 42° north, Lon. 71° west. Lat. 34° south, Lon. 18° east.
Lat. 53° north, Lon. 6° west. Lat. 41° north, Lon. 72° west.
Lat. 38° north, Lon. 9° west. Lat. 39° north, Lon. 75° west.
Lat. 46° north, Lon. 75° west. Lat. 32° north, Lon. 81° west.

PROBLEM 4.—*To find all those places that are in the same latitude or longitude as a given place.*

RULE.—Bring the given point to the brass meridian; then all the places under the meridian have the same longitude; turn the globe round, and all places which pass under the latitude of the place have the same latitude.

Q. What places have nearly the same longitude as New York?

A. Albany, Montreal, Bogota.

Q. What places are in the same latitude?

A. Boston, Madrid, Naples, Constantinople.

Q. What places have the same longitude and latitude as the following places:—

Washington, London, St. Petersburgh, Rome, Cairo, New Orleans, Mexico, Canton, Calcutta, Dublin?

PROBLEM 5.—*To find the difference of latitude between any two places.*

RULE.—Find the latitude of each place, and note it down; then if both places are on the same side of the equator, subtract the less latitude from the greater: if they are on the opposite sides of the equator, add the latitudes.

Q. What is the difference of latitude between New York and London?

A. New York 41° north, London 51° north; difference, 10 degrees.

Q. What is the difference of latitude between Washington and Cape Horn?

A. Washington 37° north, Cape Horn, 56° south.—Sum 93 degrees.

Q. Find the difference of latitude between the following places:—

New Orleans and Quebec.	Mexico and Rio Janeiro.
Madrid and Cairo,	Pekin and Botany Bay,
St. Petersburgh and Rome,	Cape of Good Hope & Cape Horn

PROBLEM 6.—*To find the difference of longitude between any two places.*

RULE.—Find the longitude of each place, and note it down; then, if both places are east or west of the meridian, subtract the less longitude from the greater; but if one is east and the other west add the longitudes.

Q. What is the difference of longitude between New York and New Orleans?

A. New York 74°; New Orleans, 90° west—difference 16 degrees.

Q. What is the difference in longitude between Boston and Rome?

A. Boston 71° west; Rome 12° east—sum, 83 degrees.

[If the sum of the longitudes exceed 180 degrees, subtract it from 360 degrees; the remainder will be the difference in longitude; as, Astoria 124° west; Pekin 116° east=240: 360—240=120° difference in longitude.

PROBLEM 7.—*The hour of the day at any place being given, to find what o'clock it is at any other place.*

RULE.—Bring the place at which the time is given to the brass meridian; set the index to the given hour, then turn the globe till the proposed place comes to the meridian; the index will point to the hour required. If the place required is east of the given place, it is later; if to the west, it is earlier.

Q. When it is noon in New York, what is the time in London?

A. 4 o'clock, 56 minutes.

Q. When it is noon at Washington, what is the hour at

New Orleans,	Mexico,	Quebec,	Boston,
Astoria,	Pekin,	Cape Horn,	Rome,
St. Petersburgh,	Moscow,	Canton,	Dublin?

Q. When it is midnight at New York, what is the hour at

Paris,	Cairo,	Calcutta,	St. Helena,
Gibraltar,	Havana,	Constantinople,	Mexico,
Astoria,	Nankin,	Tunis,	Cadiz?

PROBLEM 8.—*The hour of the day being given at any place, to find all places on the globe where it is then noon, or any other given hour.*

RULE.—Bring the place to the brass Meridian; set the index to the hour of that place; turn the globe till the index points to the other given hour; then all places under the brass meridian will be the places required.

PROBLEM 9.—*To find the Antoeci of any place.*

RULE.—Bring the place to the brass meridian, and find its latitude, then, under the same degree of latitude, on the opposite side of the equator will be the *Antoeci.*

PROBLEM 10.—*To find the Perioeci of any place.*

RULE.—Bring the given place to the brass meridian, and set the index to twelve; turn the globe till the index points to the other twelve, and under the same degree of latitude will be the *Perioeci.*

PROBLEM 11.—*To find the Antipodes of any place.*

RULE.—Bring the place to the brass meridian, and find its latitude; set the index to twelve, and turn the globe till the index points to the other twelve; then under the same degree of latitude, on the other side of the equator, will be the *Antipodes.*

PROBLEM 12.—*To find the distance in miles between any two places on the globe.*

RULE.—Lay the quadrant of altitude over the two places, so that the division marked 0 will be on one of the places, and it show the number of degrees between them; which, multiplied by 69½, will give the distance in miles.

PROBLEM 13.—*To find the Sun's Longitude or place in the Ecliptic, and his declination, in any given month or day.*

RULE.—Look for the given day in the circle of months on the wooden horizon, and opposite to it, in the circle of signs, are the sign and degree in which the sun is for that day. Find the same

sign and degree in the ecliptic on the surface of the globe; bring the degree of the ecliptic, thus found, to the brass meridian, and the degree of the meridian will be the declination.

PROBLEM 14.—*To find the time at which the Sun rises and sets at any place, the day in the year and the length of the day and night at that place.*

RULE.—Raise the pole (of the hemisphere in which the place is situated) as many degrees above the horizon as are equal to the latitude of the place; bring the sun's place on the given day, to the meridian, and set the index to 12: bring the sun's place to the eastern horizon, and the index will show the time of the sun's rising; bring the sun's place to the western edge of the horizon, and the index will show the hour of setting. Double the time of the sun's setting, and the length of the day will be had; double the time of the sun's rising, and the length of the night will be had.

PROBLEM 15.—*To find the length of the longest and shortest days and nights at any place on the earth.*

RULE.—If the place is in the northern hemisphere, elevate the north pole till the horizon cuts the brass meridian in the degree corresponding to the latitude of the place; bring the first degree of Cancer to the meridian, and set the index to 12; find the sun's place in the ecliptic, (by problem 13), and bring it to the eastern edge of the horizon, and the index will show the hour of the sun's rising; double this time, and it will give the length of the longest night. Bring the sun's place to the western edge of the horizon, and the index will show the hour of setting; double this time, and you will have the length of the longest day at that place. If the place is in the southern hemisphere, elevate the south pole to correspond with the latitude of the place; bring the first degree of Capricorn to the meridian, and proceed as above.

Q. What is the length of the longest day and shortest night at New York?

A. Longest day, 14h. 56m.; shortest night, 9h. 4m.

PROBLEM 16.—*To find those places where the sun does not rise or set on a given day.*

RULE.—Find the sun's declination on the given day, (by prob. 13), raise the pole (nearest the sun's place), as many degrees above the horizon as are equal to the declination; turn the globe round on its axis, and at all places that do not come above the horizon the sun does not rise on that day; and at all places around the other pole that do not pass below the horizon, the sun does not set on that day.

PROBLEMS

PERFORMED WITH THE CELESTIAL GLOBE.

[Latitude, on the Celestial Globe, is reckoned 90° either north or south, on circles of Celestial Latitude, which are at right angles to the ecliptic. (*See* DIAGRAM, page 65).

Longitude, on the Celestial Globe, is reckoned on the ecliptic, from the first degree of ARIES, eastward, round the globe.

Declination, is reckoned from the equinoctial, either north or south.

Right Ascension, is reckoned on the equinoctial, from the first degree in ARIES, eastward, round the globe.]

PROBLEM 1.—*To find the Right Ascension and Declination of the Sun or a Star.*

RULE.—Bring the sun or star to that part of the brass meridian which is numbered from the equinoctial towards the poles: the degree on the brass meridian, over the place, will show the declination; and the number of the degrees on the equinoctial, between the brass meridian and the first point of ARIES, is the right ascension.

Required—the right ascension and declination of the following stars:

Aldebaran, in Taurus,	Arcturus, in Bootes,
Sirius, in the Great Dog,	Capella, in Auriga,
Vega, in the Harp,	Regulus, in Leo.

PROBLEM 2.—*To find the Latitude and Longitude of a Star.*

RULE.—Place the end of the quadrant of altitude, which is marked 90°, on the north or south pole of the ecliptic, according as the star is north or south of the ecliptic; then move the other end till the graduated edge of the quadrant comes to the star. The number of degrees on the quadrant, between the ecliptic and the star, is the latitude; and the number of degrees on the ecliptic, reckoned eastward, from the first point of Aries to the quadrant, is the longitude.

EXAMPLE.—*Required*, the latitudes and longitudes of the following stars:—

Aldebaran, in Taurus. *Ans.* Latitude 5° 28′ S.; longitude, 2 signs 6° 53′, or 6° 53′ in Gemini.

Deneb, in the Swan,	Altair, in the Eagle,
Antares, in Scorpio,	Rigel, in Orion,
Fomalhaut, in the S. Fish.	Pollux, in Gemini.

PROBLEM 3.—*The declination and right ascension of a Star, the Moon, a Planet, or a Comet, being given, to find its place on the globe.*

RULE.—Bring the given degrees of right ascension to that part of the brass meridian which is numbered from the equinoctial towards the poles; then under the given declination on the brass meridian you will find the star or planet.

Q. What stars have the following right ascensions and declinations?

Right Ascension.	Declination.	Right Ascension.	Declination.
76° 14′	8° 27′ S.	86° 13′	44° 55′ N.
83 6	34 11 S.	99 5	16 26 S.
25 54	19 50 N.	11 11	59 38 N.
53 54	23 29 N.	46 32	9 34 S.

PROBLEM 4.—*The latitude and longitude of the Moon, a Star, or a Planet, being given, to find its place on the Globe.*

RULE.—Screw the quadrant of altitude on the pole of the ecliptic, and place the other end on the given degree of longitude in the ecliptic; then, under the given latitude, on the graduated edge of the quadrant, you will find the star, or place of the moon or planet.

2. What stars have the following latitudes and longitudes?

Latitudes.	Longitudes.	Latitudes.	Longitudes.
16° 3′ S.	2s 25° 51′	10° 4′ N.	3s 17° 21′
22 52 N.	2 18 57	21 6 S.	11 0 56
5 29 S.	2 6 53	12 3 S.	1 11 25
44 20 N.	7 9 22	0 27 N.	4 26 57

PROBLEM 5.—*The latitude of a place, the day and hour being given to place the Globe in such a manner as to represent the heavens at that time in order to point out the situations of the constellations and remarkable stars.*

RULE.—Elevate the pole for the latitude of the place, and set the globe due north and south by a meridian line; find the sun's place in the ecliptic, bring it to the brass meridian, and set the index to 12. If the time be afternoon, turn the globe westward; if in the forenoon, turn the globe eastward, till the index points to the given hour. The surface of the globe then represents the appearance of the heavens at that time and place.

PROBLEM 6.—*To find the distance of the Stars from each other, in degrees.*

RULE.—Lay the quadrant of altitude over any two stars, so that the division marked 0 may be on one of the stars; the degrees between them will show their distance, or the angle which these stars subtend, as seen from the earth.

EXAMPLE.—What is the distance, in degrees, between the two stars, Vega and Altair?

A. 34 degrees.

Also, between Regulus and Procyon,
" " Aldebaran and Sirius,
" " Arcturus and Spica,
" " Capella and the North Star?