FOURTEEN WEEKS

IN

DESCRIPTIVE ASTRONOMY.

BY

J. DORMAN STEELE, PH.D.

AUTHOR OF THE FOURTEEN-WEEKS SERIES IN PHYSIOLOGY, PHILOSOPHY, CHEMISTRY, AND GEOLOGY.

"The heavens declare the glory of God; and the firmament showeth his handy-work." PSALM xix. 1.

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THE SOLAR SYSTEM.

THE Solar System is mainly comprised within the limits of the Zodiac. It consists of—

1. The Sun—the centre.
2. The major planets—Vulcan (undetermined), Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.
3. The minor planets, at present one hundred and seventeen in number. (The paths of some extend a little outside the Zodiac.)
4. The satellites or moons, eighteen in number, which revolve around the different planets.
5. Meteors and shooting-stars.
6. Nine comets whose orbits have been computed, and over two hundred of which little is known.
7. The Zodiacal Light.

HOW WE ARE TO IMAGINE THE SOLAR SYSTEM TO OURSELVES.—We are to think of it as suspended in space; being held up, not by any visible object, but in accordance with the law of Universal Gravitation discovered by Newton, whereby each planet attracts every other planet and is in turn attracted by all. First, the Sun, a great central globe, so vast as to overcome the attraction of all the planets, and compel them to circle around him; next, the planets, each turning on its axis while it flies around the

sun in an elliptical orbit; then, accompanying these, the satellites, each revolving about its own planet, while all whirl in a dizzy waltz about the central orb; next, the comets, rushing across the planetary orbits at irregular intervals of time and space; and finally, shooting-stars and meteors darting hither and thither, interweaving all in apparently inextricable confusion. To make the picture more wonderful still, every member is flying with an inconceivable velocity, and yet with such accuracy that the solar system is the most perfect timepiece known.

THE SUN.

Sign, ⊙, a buckler with its boss.

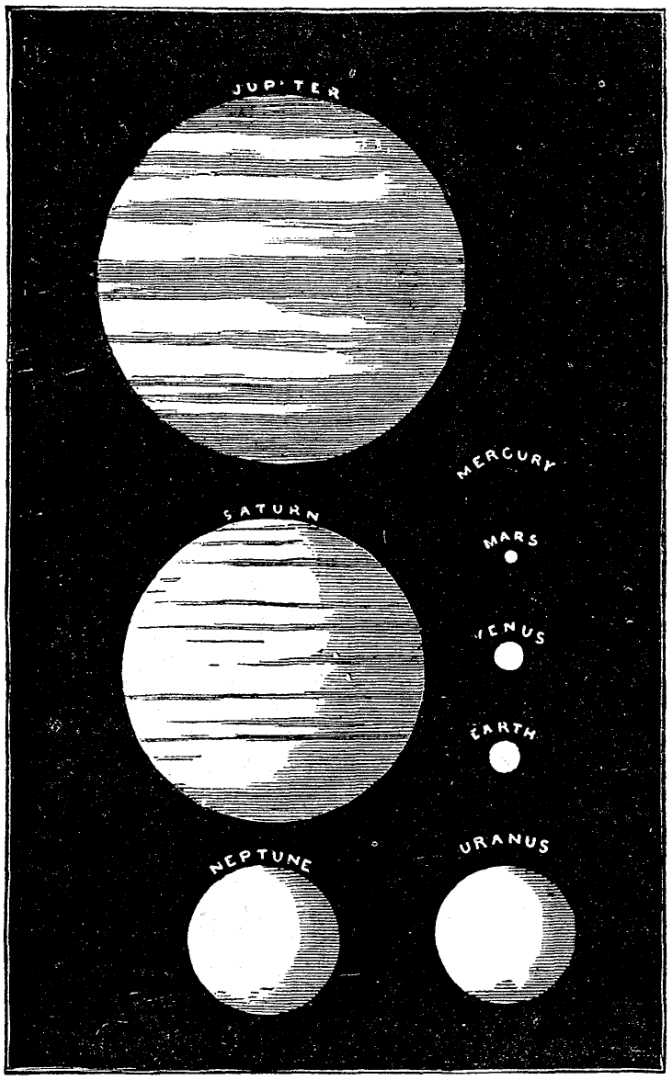
DISTANCE.—The sun's average distance from the earth is about 91½ million miles. Since the orbit of the earth is elliptical, and the sun is situated at one of its foci, the earth is nearly 3,000,000 miles further from the sun in aphelion than in perihelion. As we attempt to locate the heavenly bodies in space, we are immediately startled by the enormous figures employed. The first number, 91,500,000 miles, is far beyond our grasp. Let us try to comprehend it. If there were air to convey a sound from the sun to the earth, and a noise could be made loud enough to pass that distance, it would require over fourteen years for it to come to us. Suppose a railroad

incline it slightly, as compared with some other fixed plane ring, as in the cut. The astronomical fixed plane is the ecliptic. Imagine a planet following the inclined ellipse; at some point it must rise above the level of the fixed plane: this point is called the *ascending node*, and the opposite point of intersection is termed the *descending node*. A line connecting the two nodes is called the *line of the nodes*. The *longitude of the node* is its distance from the first point of Aries, measured on the ecliptic, eastward. In this way we can get a very correct idea of a planetary orbit in space.

COMPARATIVE SIZE OF PLANETS. (*Chambers.*)—The following scheme will assist in obtaining a correct notion of the magnitude of the planetary system. Choose a level field or common; on it place a globe two feet in diameter for the Sun: Vulcan will then be represented by a small pin's head, at a distance of about 27 feet from the centre of the ideal sun; Mercury by a mustard-seed, at a distance of 82 feet; Venus by a pea, at a distance of 142 feet; the Earth, also, by a pea, at a distance of 215 feet; Mars by a small pepper-corn, at a distance of 327 feet; the minor planets by grains of sand, at distances varying from 500 to 600 feet. If space will permit, we may place a moderate-sized orange nearly one-quarter of a mile distant from the starting point to represent Jupiter; a small orange two-fifths of a mile for Saturn; a full-sized cherry three-quarters of a mile distant for Uranus; and lastly, a

plum $1\frac{1}{4}$ miles off for Neptune, the most distant planet yet known. Extending this scheme, we should find that the aphelion distance of Encke's comet would

Fig. 16.



COMPARATIVE SIZE OF PLANETS.

be at 880 feet; the aphelion distance of Donati's comet of 1858 at 6 miles; and the nearest fixed star at 7,500 miles.

According to this scale, the daily motion of Vulcan in its orbit would be $4\frac{2}{3}$ feet; of Mercury, 3 feet; of Venus, 2 feet; of the Earth, $1\frac{7}{8}$ feet; of Mars, $1\frac{1}{2}$ feet; of Jupiter, $10\frac{1}{2}$ inches; of Saturn, $7\frac{1}{2}$ inches; of Uranus, 5 inches; and of Neptune, 4 inches. This illustrates the fact that the orbital velocity of a planet decreases as its distance from the sun increases.

CONJUNCTIONS OF PLANETS.—The grouping together of two or more planets within a limited area of the heavens is a rare event. The earliest record we have is the one of Chinese origin, already mentioned on page 16, wherein it is stated that a conjunction of Mars, Jupiter, Saturn, and Mercury occurred in the

Fig. 17.

VENUS AND JUPITER IN CONJUNCTION, JANUARY 30, 1868.

reign of the Emperor Chuenhio. Astronomers tell us that this actually took place Feb. 28, 2446 B. C., and that they were between 10° and 18° of Pisces. This was before the Deluge, so that the fact must

PLANETS AS EVENING AND MORNING STARS.—The inferior planets are evening stars from superior to inferior conjunction, and the superior planets from opposition to conjunction. During the other half of their revolutions they are morning stars.

Mercury,	evening	star	2	months.
Venus,	"	"	$9\frac{1}{2}$	"
Mars,	"	"	13	"
Jupiter,	"	"	$6\frac{1}{2}$	"
Saturn,	"	"	6	"
Uranus,	"	"	6	"

To avoid filling the text with a multiplicity of figures, many interesting items are condensed in tables at the close of the volume.

VULCAN.

SUPPOSED DISCOVERY.—Le Verrier, having detected an error in the assumed motion of Mercury, suggested, in the fall of 1859, that there may be an interior planet, which is the cause of this disturbance. On this being made public, M. Lescarbault, a French physician, and an amateur astronomer, stated that on March 26 of that year he had seen a dark body pass across the sun's disk, and that this might have been the unknown planet. Le Verrier visited him, and found his instruments rough and home-made, but singularly accurate. His clock was a simple pendulum, consisting of an ivory ball hang-

ing from a nail by a silk thread. His observations were on prescription paper, covered with grease and laudanum. His calculations were chalked on a board, which he planed off to make room for fresh ones. Le Verrier became satisfied that a new planet had been really discovered by this enthusiastic observer, and congratulated him upon his deserved success. On March 20, 1862, Mr. Lummis, of Manchester, England, noticed a rapidly-moving, dark spot, apparently the transit of an inner planet. Many other instances are given of a somewhat similar character. As yet, however, the existence of the planet is not generally conceded. The name Vulcan and the sign of a hammer have been given to it. Its distance from the sun has been estimated at 13,000,000 miles, and its periodic time (its year) at 20 days.

MERCURY.

The fleetest of the gods. Sign, ☿, his wand.

DESCRIPTION.—Mercury is nearest to the sun of any of the definitely known planets. When the sky is very clear, we may sometimes see it, just after the setting of the sun, as a bright sparkling star, near the western horizon. Its elevation increases evening by evening, but never exceeds 30°.* If we watch it closely, we shall find that it again ap-

* This distance varies much, owing to the eccentricity of Mercury's orbit.

a planet in this space. This supposition was corroborated by Titius's discovery of what has since been known as Bode's law.

Take the numbers 0, 3, 6, 12, 24, 48, 96, 192, 384, each of which, after the second, is double the preceding one. If we add 4 to each of these numbers, we form a new series:

4, 7, 10, 16, 28, 52, 100, 196, 388.

At the time this law was discovered, these numbers represented very nearly the proportionate distance from the sun of the planets then known, taking the earth's distance as ten, except that there was a blank opposite 28.* This naturally led to inquiry, and a systematic effort to solve the mystery. On the 1st day of January, 1801, the nineteenth century was inaugurated by Piazzi's discovery of the small planet Ceres, at almost the exact distance necessary to fill the gap in Bode's series. This was soon followed by the announcement of other new planets, until (1870) there are one hundred and twelve, and a probability of many more. Indeed, Leverrier has calculated that there may be perhaps 150,000 in all

* PLANETS.	True distance from ☉.	Distance by Bode's law.	PLANETS.	True distance from ☉.	Distance by Bode's law.
Vulcan.....			Ceres	27.66	28.00
Mercury	3.87	4.00	Jupiter	52.03	52.00
Venus	7.23	7.00	Saturn.....	95.39	100.00
Earth	10.00	10.00	Uranus	191.82	196.00
Mars	15.23	16.00	Neptune.....	300.37	388.00

DESCRIPTION.—These minor worlds, or "pocket planets," as Herschel styled them, are extremely diminutive. The largest of them is Pallas, whose diameter is perhaps 600 miles. Those recently discovered are so small that it is difficult to decide which is the smallest. A French astronomer recently remarked concerning them, that a "good walker could easily make the tour of one in a day;" a prairie farmer would need to pre-empt a whole one for a flourishing cornfield. They all revolve about the sun in regular orbits, comprising a zone about 100,000,000 miles in width. Their paths are variously inclined to the ecliptic; Massilia's 41′, while that of Pallas rises 34°.

ORIGIN.—One theory concerning the origin of these small planets is, that they are the fragments of a large planet which, in a remote antiquity, has been shivered to pieces by some terrible catastrophe. "One fact seems above all others to confirm the idea of an intimate relation between these planets. It is this: if their orbits consisted of solid rings, they would be found so entangled that it would be possible, by taking up any one at random, to lift all the rest." Another theory is given under the "Nebular Hypothesis."

Names and signs.—Ceres, the first discovered, received the symbol ♀, a sickle. This was appropriate, since that goddess was supposed to preside over harvests. Pallas, the second, named from the goddess of wisdom and scientific warfare, obtained the

APPENDIX.

TABLE ILLUSTRATING KEPLER'S THIRD LAW. (CHAMBERS.)

In the first column are the relative distances of the planets from the sun; in the second, the periodic times of the planets; and in the third, the squares of the periodic times divided by the cubes of the mean distances. The decimal points are omitted in the third column for convenience of comparison. The want of *exact uniformity* is doubtless due to errors in the observations.

Vulcan ?	.143	19.7	132 716
Mercury.	.38710	87.969	133 421
Venus.....	.72333	224.701	133 413
Earth	1.	365.256	133 408
Mars.....	1.52369	686.979	133 410
Jupiter.....	5.20277	4,332.585	133 294
Saturn.....	9.53878	10,759.220	133 401
Uranus.....	19.18239	30,686.821	133 422
Neptune.....	30.03680	60,126.710	133 405

Arago, speaking of Kepler's Laws, says: "These interesting laws, tested for every planet, have been found so perfectly exact, that we do not hesitate to infer the distances of the planets from the sun from the duration of their sidereal periods; and it is obvious that this method possesses considerable advantages in point of exactness."

MEASUREMENTS OF THE EARTH'S DIAMETER.

	Airy.	Bessel.
Polar diameter.....	7899.17	7899.11
Equatorial diameter	7925.64	7925.60
Compression	26.47	26.49