

THE MYSTERIOUS PLANET SATURN.

BY FELIX ERBER.

ON a memorable evening in the year 1610 Galileo sat in the tower of his observatory in Florence, and gazed through his newly-invented "perspective glass" at Saturn, which was then regarded as the most distant of the planets. The astronomer was astonished to see the planet flanked by two smaller globes, one on each side, and with characteristic prudence, and in accordance with the fashion of the age, he made a record of his discovery in the form of an anagram, which admitted an almost infinite number of interpretations, and sorely tried the patience of the indomitable Kepler, until the answer to the riddle appeared in Galileo's letter to Giuliano de' Medici. Two years later, however, Galileo found that these attendants of Saturn had vanished. The inexplicable character of these discoveries is said to have vexed Galileo so greatly, that he never deigned to cast another glance on the mysterious planet.

Later observers have been deceived in the same way. Saturn surrounded by its rings appeared to Scheiner and Hevel, in 1614, as a disk with two projecting ears. The Jesuit priest Eustachius de Divinis, in 1647, and Riccioli, in 1648, made a close approximation to the real form of the planet, but the mathematically-trained Huygens, in 1655, first described it

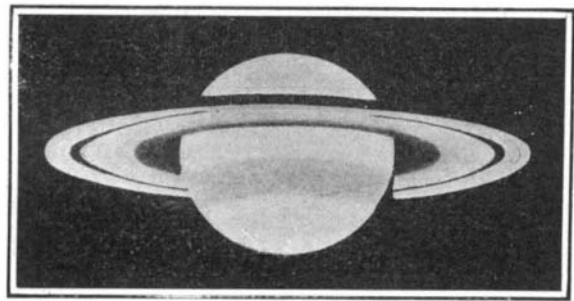


FIG. 1.—SATURN AND ITS RINGS, AS DRAWN IN 1894 BY LEO BRENNER, DIRECTOR OF THE MANORA OBSERVATORY AT LUSSINPICCOLO.

1. Encke's line. 2. Cassini's division. 3. The gauze or crape ring.

correctly as being "surrounded by a thin flat ring, nowhere in contact with it, and inclined to the ecliptic."

Saturn, with its rings and satellites, forms so true a picture of an early stage in the development of the solar system according to Laplace's theory of cosmogony, that one is almost tempted to regard it as a living proof of the correctness of that hypothesis.

* From the newer and more probable meteoric theory the late English astronomer Proctor derived the conclusion that Saturn is the second planet of the solar system in order of creation. This theory assumes that in the beginning the entire field of the solar system was filled with solid particles of cosmical matter which, coalescing in consequence of mutual collisions, formed first a principal nucleus of attraction (the sun) and then subordinate nuclei (the planets), each of which, as it revolved around the sun, captured all the remaining particles that came within its sphere of attraction.

Saturn is but faintly illuminated by the sun, its mean distance from which is nearly 900 million miles. The Hindus called it "Sanaistshara," (slowly moving—a name given also to Vishnu in the Vedas), because the planet so leisurely follows the eastward course of the sun among the stars, tarrying two years and six

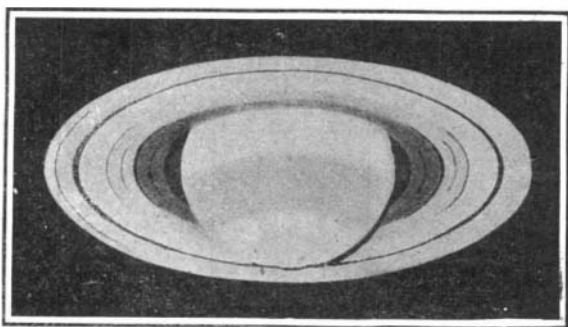


FIG. 2.—SATURN AND ITS RINGS, AS DRAWN IN 1898 BY LEO BRENNER.

1. Encke's pencil line. 2. Cassini's division. 3. Secchi's line. 4. Bond's line. 5. Manora line. 6. Struve's line.

months in each constellation of the zodiac, through which the sun passes in a single month. This apparent motion of the planet, however, is not uniform, but is affected by the periodic shifting of our point of view, the earth, so that Saturn is not always easily found and distinguished among the stars.

When the planet is viewed through a large telescope, it is seen to be greatly flattened at the poles. Saturn has been weighed in the astronomer's balance, and found to contain twice as much matter as Mercury, Venus, the earth, Mars, Uranus, and Neptune combined. Its mass is 93 times that of the earth, and Jupiter alone exceeds it in magnitude. The equatorial diameter of Saturn is about 73,000 miles, but the polar diameter is only 66,000 miles. The great planet consumes 29½ of our years in making one revolution around the sun, from which its mean distance is about

895 million miles. At this distance the intensity of solar radiation is only 1.90 of that which falls on the earth. It might be inferred from this fact that Saturn must have an Arctic climate and be covered with glaciers, but ice caps, like those of Mars, have never been observed at the poles of Saturn.



FIG. 3.—SATURN'S RINGS AS THEY WOULD APPEAR TO AN OBSERVER ON THE PLANET, FIFTY DEGREES FROM THE EQUATOR.

Hence we are justified in assuming that Saturn still hot and, to some extent, self-luminous. Very probably it is yet in the stage of crust formation and preparation for the development of organic life, or in the stage of cooling through which the earth passed millions of years ago, when it was covered with forests of huge ferns and grasses and inhabited by gigantic saurians.

Each of the four seasons of Saturn's year continues through seven of our years. The inclination of its equator to the plane of its orbit, 27 degrees, is such as to make the distribution of climate and the phenomena of change of seasons similar to those of Mars and the earth. Saturn not only possesses an atmosphere, in which Joussen has found spectroscopic indications of the presence of hydrogen, but is enveloped in a mantle of dense clouds, as the earth was millions of years ago and Jupiter is to-day.

The spectrum of Saturn is very similar to that of Jupiter. Both show dark absorption bands in the red and orange, which point to a close resemblance in the physical constitution of the two great planets. In the vapors which envelop both, also, peculiar cloud masses have been observed, including dark bands parallel to the equator. In the case of Saturn these phe-

or "gauze" ring. The mean time of rotation of the rings, however, is greater than this, and is estimated as equal to 10 hours and 29 minutes, a value almost identical with that given by Laplace.

The series of nearly concentric rings that encircle Saturn in the equatorial plane appears like a survival

of primordial conditions. It is the most astonishing object that is visible in the solar system or that could well be imagined. There are three principal rings and several minor subdivisions. The innermost, dimly-shining ring, called the "gauze" or "crape" ring, begins at a distance of 6,400 miles from the surface of the planet, and is 8,400 miles wide. This ring was discovered in 1836 by Galle, the discoverer of Neptune, and was carefully studied by Bond and Dawes. Astronomers have detected or fancied numerous subdivisions in this faint ring, which is now generally regarded as a cloud of cosmical dust, similar to the cloud that causes the phenomenon of the zodiacal light. The disk of Saturn is seen through this ring in undiminished brightness, and in May, 1905, Saturn's satellite Iapetus passed boldly through the gauze ring. The circumstances and consequences of this passage proved that the gauze ring is composed of separate particles, which are either smaller or less closely aggregated than those which form the outer rings. The gauze ring merges by imperceptible gradations into a moderately bright ring about 18,000 miles wide, which is separated by an interval of 1,450 miles known as "Cassini's division," from the outer very bright ring, the breadth of which is 10,000 miles. The outer edge



FIG. 4.—SATURN'S RINGS AS THEY WOULD APPEAR TO AN OBSERVER ON THE PLANET, SEVENTY DEGREES FROM THE EQUATOR.

nomena are very variable, and are indistinct because of the feeble illumination which the planet receives from the sun. From them, however, Sir William Herschel computed the period of rotation at 10 hours and 16 minutes.

In 1876 a very bright spot appeared near the equator of Saturn, and remained visible for several months. Like the red spot once seen on Jupiter, it was probably the result of some great convulsion on the surface of the planet. From the motion of this spot, Prof. Asaph Hall, director of the Naval Observatory at Washington, deduced a period of rotation of 10 hours, 14 minutes, and 24 seconds. These figures, however, were only provisional. The atmospheric strata of Saturn do not rotate at the same rate as the body of the planet, and, moreover, these spots and clouds have relative motion with respect to the atmosphere. In 1903 very conspicuous but variable dark and bright spots appeared on the northern hemisphere of Saturn, indicating another series of great atmospheric disturbances.

From all the spectroscopic and other observations which bear upon the rotation of Saturn, a period of 10 hours, 14 minutes, and 6 seconds—nearly identical with Hall's result—has been deduced as the most probable value. This rapid rotation greatly reduces the weight of objects at the equator, where gravity would be entirely neutralized by centrifugal force if

of the exterior ring is about 45,000 miles distant from the surface of the planet. This remarkable series of rings, which surrounds Saturn as the brim of a hat surrounds the wearer's head, possesses no atmosphere, for the characteristic atmospheric line in the red is absent from its spectrum.

Twice in each revolution of the planet about the sun the rings vanish or dwindle to a narrow line, and twice they open into the broad ovals shown in Fig. 2. These are the changes which so greatly puzzled and annoyed Galileo. When the plane of the rings passes through the sun, an event which occurs whenever, as at present, Saturn in opposition is found in the constellation Pisces or the constellation Leo, the rings disappear. When the planet is in opposition in Sagittarius, or between Taurus and Gemini, the rings appear broadest, and Saturn shines more brightly than a star of the first magnitude. Finally, when the rings are invisible and the planet near conjunction, it appears like a star of the magnitude 1½. An interval of seven years and four months elapses between the maximum brightness and the disappearance of the rings as described above. But the rings are likewise invisible whenever their plane passes between the earth and the sun, because their illuminated side is turned away from us. In this case we see only the shadow cast by the rings on the planet. A very fine

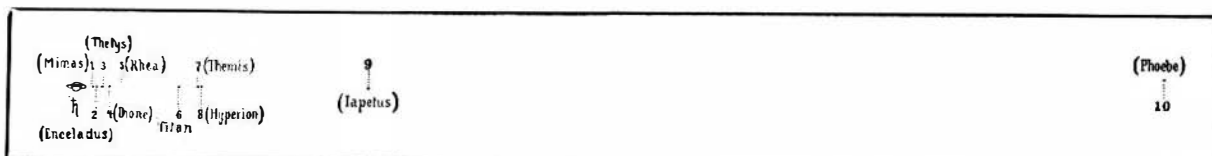


FIG. 5.—RELATIVE DISTANCES OF THE SATELLITES FROM SATURN.

The actual mean distance between Saturn and Phoebe is 8,000,000 miles.

the planet rotated 2½ times faster than it actually does.

For the time of rotation of Saturn's ring, Laplace gave the value 10 hours, 29 minutes, and 17 seconds. More recent observations give 7 hours and 45 minutes for the inner edge of the first bright ring, and 5 hours and 39 minutes for the inner edge of the innermost,

drawing of the shadow as observed in 1856 was made by Secchi, and the shadow has often been drawn from observation by other astronomers. From the breadth of the shadow it is inferred that the rings are about 60 miles thick. To an inhabitant of Saturn the rings would present a wonderful picture at night, spanning the landscape like an immense rainbow, colorless but

dazzling. By day, however, they would eclipse the sun in the regions covered by their shadow.

Viewed through the small telescope of early observers, the rings appeared as one. In 1665 Ball discovered indications of the principal dark line of division, which was afterward seen more distinctly by Maraldi and Cassini and named "Cassini's division." Encke discovered a much finer line, which is called "Encke's pencil line," and later observers have increased the number of distinct rings to seven or more (Fig. 2).

The intervals between the rings may be compared with the void spaces in the asteroid belt, where asteroid orbits are made impossible by the disturbing influence of the great planets. The rings of Saturn, if they are not continuous masses of cosmical matter, must be swarms of billions of small satellites, each of which travels in its individual orbit subject to the attractions of all the rest and of all other bodies in the universe, in accordance with the inexorable law of gravitation. Probably the complex motions of this vast swarm of satellites have become so adjusted that no collisions occur.

Saturn's ring was long believed to be a continuous solid mass. Bond and Peirce regarded it as liquid, but in 1884 Pratt discovered a distinct granulation which suggested its true nature. Now we know with certainty from the photometric investigations of Seeliger, of Munich, that the rings are made up of countless separate particles, which change their relative positions, and that the apparent continuity is merely an effect of distance. The talented and prematurely deceased American astronomer Keeler proved by spectroscopic observations interpreted by Doppler's principle that the inner parts of the ring move more swiftly in a radial direction (in the line of vision) than the outer parts. Hence the ring can not be a rigid mass.

Saturn also possesses at least nine larger satellites or moons, and probably a tenth (Thermis). The following table gives the principal data concerning these satellites:

Order of Distance from Saturn	Name of Satellite	Discover.	Date of Discovery	Time of Revolution		Distance from Center of Saturn in Saturn's Radii
				Days	Hrs.	
1	Mimas.....	Sir Wm. Herschel.	1789	0	23	3
2	Enceladus.....	Sir Wm. Herschel.	1789	1	9	4
3	Thetis.....	D. Cassini.....	1684	1	21	5
4	Dione.....	D. Cassini.....	1684	2	18	6
5	Rhea.....	D. Cassini.....	1672	4	12	8 1/2
6	Titan.....	Huygens.....	1655	15	22	20
7	Hyperion.....	Bond and Lassell.	1848	21	7	24
8	Iapetus.....	D. Cassini.....	1671	79	8	57
9	Phoebe.....	H. W. Pickering.	1893	546	12	207
10	Thermis.....	H. W. Pickering.	1905			

Phoebe was first actually seen by Barnard in 1904, after its motions had been photographically traced for years. It is only about 60 miles in diameter. Its motion was long thought to be retrograde, but this question, with that of the existence of the tenth satellite, must be left to the future for final answer. The satellite Iapetus is peculiarly interesting because of its periodic changes in brightness, which are probably due to differences in the character of its surface at different points.

Our present knowledge of Saturn makes it certain that neither the planet nor its rings can be inhabited by creatures at all resembling human beings. It is not improbable, however, that the surface of the planet may have cooled sufficiently to develop a flora and a fauna similar to those which occupied the earth in the carboniferous period.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Illustrierte Zeitung.

THE NUTRITIVE VALUE OF CEREAL BREAKFAST FOODS.*

The constituents of all foods are water, protein, fats, carbohydrates, and mineral matter or ash. Water, though needed in considerable quantities by the body, is obtained from beverages as well as from solid food and does not count as one of the nutritive materials or nutrients of food. It might be left entirely out of consideration in discussions like this save that its presence in food decreases the proportion of nutrients. Protein is the foundation of all the tissues of the body and is an indispensable food ingredient. It is also the most costly of all nutrients. The carbohydrates include the various kinds of sugars and starches, commonly grouped together under the name nitrogen-free extract. Cellulose, or crude fiber, which forms the woody or straw-like framework of plants, also belongs to the carbohydrate group. It is here considered separately, because, while the other carbohydrates are valuable nutrients, crude fiber is so indigestible that it has almost no food value. It is, however, undoubtedly useful in giving the needed bulk to the food. The fats include the numerous fats and oils in the diet, like those of butter, cream, fat of meat, olive oil, etc. Mineral matter or ash includes phosphates, chlorids, and other salts of calcium, magnesium, sodium, potassium, iron, etc.

The nutrients supplied in the food enable the body to grow and to repair its tissues as they are worn out in the necessary exercise of the body functions. Another of the great uses of food is to supply the body with the energy needed for its various activities and for keeping up body heat. During digestion, assimilation and utilization, food undergoes great chemical changes in the body, many of which liberate heat. It is through such chemical processes that the energy required for internal and external muscular work is provided and the body temperature maintained. Energy may be very conveniently measured in terms of heat, the calorie* or heat unit being used for this purpose. It quite naturally follows that the amount of energy which the body gets from any food is spoken of as its fuel value. All the nutrients except mineral matters are sources of energy, but since protein, the only nutrient containing nitrogen, has tissue-building functions which the other nutrients do not possess, the body usually finds it more economical to use fat and carbohydrates largely as energy-yielding foods. As sources of energy fats are more concentrated than protein and carbohydrates, one pound of digestible fat supplying 4,260 calories of heat or energy, or about two and one-fourth times as much as a pound of protein or carbohydrates, which yields, respectively, 2,000 and 1,860 calories.

The terms digestion and digestible as commonly used frequently refer to ease or quickness of digestion or to the "agreeableness" of a given food with an individual. In physiological discussions "digestibility" more commonly refers to the thoroughness with which a food is absorbed—that is, the amount or percentage of nutrients retained by the body when food passes through the digestive tract. Digestibility may be determined by actual experiments or, when experiments cannot be conveniently undertaken, may be calculated with reasonable accuracy by the aid of standard factors, which have been derived from actual experiments.

In Table 2 the results of a large number of digestion experiments with cereal breakfast foods are summarized. These average values were used in computing the results given in Table 1, showing the average composition of various sorts of cereal breakfast foods, the proportion of digestible nutrients which they supply, and the energy of value of the digestible nutrients. For purposes of comparison some other common foods are also included in the table. In this and other tables the different cereal breakfast foods are arranged in groups, but trade names are not used. If the housewife who is interested in any special brand will take note of its physical characteristics and appearance, she should be able to determine the class in which it should be included, and so decide as to its comparative value.

Different specimens of the same grain show considerable variations in composition, depending upon such factors as the variety, the soil, the climate, and the season in which they are grown. The cereal breakfast foods and other materials prepared from the grains naturally show a corresponding range in composition, but in general are quite similar in composition to the

grains from which they are made. The methods of hulling, milling, and manipulation to which the breakfast foods and similar goods are submitted naturally exercise some effect on composition. Thus, two specimens of oatmeal may vary in the amount of crude fiber which is left in the manufactured product, or one brand of rice or pearly barley may be polished down more thoroughly than another. It is believed, however, that the figures in the annexed table, which are based on a large number of analyses, are representative, and that they show average values for various products as they are found in American markets.

The analytical data summarized in the table show that the grains and the products made of them, as is obvious from their appearance, are comparatively dry materials, the average water content of the uncooked material being not far from 10 per cent. The cereal grains and their products have a fairly high protein content, but the carbohydrates, especially nitrogen-free extract, make up the nutrient group present in the largest proportion. The fat content, though never large, varies within rather wide limits, being greatest in corn and oats and their products and lowest in rice. The proportion of ash in cereals is small, as indeed is the case with all the common food products. Some variation is observed, the coarser grain products containing rather more ash than those made up of the interior portion of the grain. Such differences are, however, too small to be of much account in an ordinary diet, since the amount of ash constituents supplied will almost always be more than sufficient for all needs.

In comparing the composition of the different cereals it is apparent that while they resemble each other closely and all are rich in carbohydrates, there are certain differences between them which are quite characteristic. Thus, corn is characterized by a relatively high proportion of fat; oats are relatively rich in both protein and fat; rice is comparatively free from crude fiber and fat; wheat and rye have a high proportion of protein with a moderate amount of fat, while barley and wild rice contain about average proportions of all the nutritive ingredients. Judged by their chemical composition alone, that is, by the total amount of nutrients furnished, of the six most important cereal grains, namely, wheat, oats, rice, corn, rye, and barley, oats appear to furnish the nutrients in better proportions than the other cereals. Wheat ranks very close to oats and corn next to wheat.

The hulling and other processes followed in the manufacture of cereal breakfast foods frequently remove some of the crude fiber of the outer layers of the grain and so many of the manufactured products contain less of this indigestible material than the original grain. In general, however, a comparison of the cereal breakfast foods and the grains from which they are made shows that the manufactured products are very similar in composition to the original grain. This is what might be expected when it is remembered that

* A calorie represents very nearly the amount of heat required to raise the temperature of 1 pound of water from 0 deg. to 4 deg. F.

TABLE 1.—TOTAL AND DIGESTIBLE NUTRIENTS AND FUEL VALUE OF CEREAL BREAKFAST FOODS AND SOME OTHER FOODS.

* Abstracted from Farmer's Bulletin 249, issued by the Department of Agriculture.