the legend that it was instituted by Romulus under the name of the Brumalia (bruma = winter solstice). The prominence given to candles at the festival points to the custom of making a new fire at this time. The custom of solemnly kindling fires at the summer solstice (Eve of St John) has prevailed in most parts of Europe, notably in Germany, and there are traces (of which the yule-log is one) of the observance of a similar custom at the winter solstice. In ancient Mexico a new fire was kindled, amid great rejoicings, at the end of every period of fifty-two years.

The designation of the planets by the names of gods is at least as old as the 4th century B.c. The first certain mention of the star of Cronus (Saturn) is in Aristotle (*Metaphysics,* p. 1073 b. 35). The name also occurs in the *Epinomis* (p. 987 b), a dialogue of uncertain date, wrongly ascribed to Plato. In Latin, Cicero (1st century b.c.) is the first author who speaks of the planet Saturn. The application of the name Saturn to a day of the week (*Saturni dies,* Saturday) is first found in Tibullus (i. 3, 18). (J. G. Fr.; X.)

SATURN, in astronomy, the sixth major planet in the order of distance from the sun, and the most distant one known before the discovery of Uranus in 1781. Its symbol is h. Its periodic time is somewhat less than 30 years, and the interval between oppositions is from 12 to 13 days greater than a year. It appears as a star of at least the first magnitude, but varies much in brightness with its orbital position, owing to the varying phases of its rings. It seems to resemble Jupiter in its physical constitution, but the belts and cloud-like features so conspicuous on that planet are so faint on Saturn that they can be seen only in a general way as a slight mottling. In colour the planet has a warmish tint, not dissimilar to that of Arcturus. Its density is the smallest known among the planets, being only 0∙13 that of the earth, and therefore less than that of water.

Owing to the difficulty of distinguishing any individual feature, the rotation of the planet has been observed only on a few rare occasions when a temporary bright spot appeared and continued during several days. The first observation of such a spot was made by the elder Herschel, who derived a rotation period of 10 h. 16 m. In December 1876 a bright spot appeared near the equator of the planet, which was observed by Asaph Hall at Washington for more than a month. It gradually spread out in longitude, and finally faded away. The time of rotation found by Hall was 10 h. 14 m. 24 s. A third spot appeared in 1903 on the northern hemisphere, and had a rotation period of about 10 h. 38 m. The deviation of this period from the others indicates that, as in the case of Jupiter and the sun, the time of rotation is least at the equator, and increases toward the poles. Both from this difference and from the appearance presented by the planet it is clear that the visible surface is not a solid, as in the case of Mars, but consists of a layer of cloudy or vaporous matter, which conceals from view the solid body of the planet, if any such exists. Owing to the rapid rotation the figure of the disk is markedly elliptical, but when, owing to the rings being seen edgewise, the entire disk is visible, the latter sometimes seems to have the form of a square with its edges rounded off. This may be an illusion.

The most remarkable feature associated with Saturn is its magnificent system of ring and satellites. The former is unique in the solar system. The ring, the seeming ends of which were first seen by Galileo as handles to the planet, was for some time **a** mystery. After Galileo had seen it at one or two oppositions, it faded from sight, a result which we now know was due to the advance of the planet in its orbit, bringing our line of sight edgeways to the ring. When it reappeared, Galileo seems to have abandoned telescopic observation, but the “ ansae” of Saturn remained a subject of study through a generation of his successors without any solution of their mystery being reached. The truth was at length worked out in 1656 by Huygens, who first circulated his solution in the form of an anagram. When arranged in order the letters read:

“ Annulo cingitur tenui, plano, nusquam cohaerente, ad eclipticam inclinato.”

This designation of a plain thin ring surrounding the planet, but disconnected from it, and inclined to the ecliptic, is accurate and as complete as the means of observation permitted.

The varying phases presented by the ring arise from its having an inclination of 27° to the orbit of the planet, while its plane remains

invariable in direction as the planet performs its orbital revolution. There are therefore two opposite points of the orbit, at each of which the plane of the ring passes through the sun, and is seen nearly edgeways from the earth. At the two intermediate points the ring is seen as opened out at an angle of 27°. The apparent illuminated surface which it then presents to us exceeds that presented by the planet, so that the brightness of the entire system to the naked eye is more than double.

In 1665 William Ball or Balle, joint-founder and first treasurer of the Royal Society, discovered that the ring was apparently formed of two concentric rings, separated by a fine dark line. This was afterwards independently discovered by G. D. Cassini at the Paris Observatory. As the telescope was improved, yet other shaded lines concentric with the ring itself were found. These were sometimes regarded as divisions, but if they are such they are by no means complete and sharp. The universal rule is that, if we con­sider any portion of the ring contained between two circles concentric with the ring itself, the general aspect and brightness of this circular portion are alike through its whole circumference. That is to say, if the brightness of different parts of the ring be compared, it is found to be constant when the parts compared are equally distant from the centre, but subject tp variation as we pass from the circumference towards the centre. The inner and broader of the two rings is brightest near the outer part and shades off toward the planet, gradually at first, and more rapidly afterwards. Its inner portion is so dark that it was at one time regarded as separate, and called the “crape” or “dusky” ring. This supposed discovery of an inner ring was made independently by W. R. Dawes of England and G. P. Bond of the Harvard Observatory, though J. G. Galle at Berlin noticed the actual appearance at an earlier date. The more powerful telescopes of the present time show this dusky ring to be continuous with the inner portions of the main ring, and transparent, at least near its inner edge.

The physical constitution of the rings is unlike that of any other object in the solar system. They are not formed of a continuous mass of solid or liquid matter, but of discrete particles of unknown minuteness, probably widely separated in proportion to their individual volumes, yet so close as to appear continuous when viewed from the earth. This constitution was first divined by Cassini early in the 18th century. But, although the impossibility that a continuous ring could surround a planet without falling upon it was shown by Laplace, and must have been evident to all investigators in celestial mechanics, Cassini’s explanation was forgotten until 1848. In that year James Clerk Maxwell, in an essay which was the first to gain the newly-founded Adams prize of the university of Cambridge, made an exhaustive mathematical in­vestigation of the satellite constitution, showing that it alone could fulfil the conditions of stability. Although this demonstration placed the subject beyond doubt, it was of great interest when J. E. Keeler at the Allegheny Observatory proved this constitution by spectroscopic observation in 1895. He found by measuring the velocity of different parts of the ring to or from the earth that, as we pass from the outer to the inner regions of the ring, the velocity of revolution around the planet increases, each concentric portion of the ring having the speed belonging to a satellite revolving in a circular orbit at the same distance from the planet.

A remarkable feature of the rings is that they are so thin as to elude measurement and nearly disappear from view when seen edgeways even in powerful telescopes. As this can happen only at the rare moments when the plane of the ring passes accurately through the earth, precise observations of the phenomenon with powerful telescopes are few. But before or after the epochs at which the plane passes through the sun, there is sometimes a period of several weeks, during which the sun shines on one face of the ring while the other is presented to the earth. In October 1907 the appearance presented by the rings was studied by W. W. Campbell at the Lick Observatory, and E. E. Barnard at the Yerkes Ob­servatory. The position of the ring as seen against the planet is marked by a dark line stretching across the equator, which is the thin shadow of the ring, on which the sun shines at a very acute angle.

An interesting question still open is the nature of the so-called divisions of the rings. Are these divisions real or are they simply apparent, arising from a darker colour in the matter which composes them? In the case of the sharpest and best-known division, to which the name of Cassini has been given from its first observer, there would seem to be little doubt that the division is real. But there is some doubt in the case of the other divisions. While many excellent observers have sometimes thought they saw a complete separation between the bright and the crape rings, no such pheno­menon has been seen in the great telescopes of our times, and it is almost certain that the dark colour of the crape ring arises merely from its tenuity and transparency. From Barnard’s observation of the passage of Japetus through the shadow of Saturn and its rings it appears that the transparency gradually diminishes from the centre of this ring to its line of junction with the bright ring. If there should ever be a transit of Saturn centrally past a bright star, many questions as to the constitution of the rings may be settled by noting the times at which the star was seen through the divisions of the ring.