Planetary Photography*

By DR. V. M. SLIPHER

THE Lowell Observatory was founded in 1894, by the late Percival Lowell, who maintained and directed it during his lifetime and endowed it by his will, that it might permanently continue astronomical research and in particular that of the planets. For nearly four decades now, it has been occupied with planetary investigations. It is situated at Flagstaff, Arizona, because, of the numerous places he had tested, it was here that Lowell found the conditions best for planetary studies. The major instruments of the Observatory are: (1) 24-inch aperture Clark refractor of 32 feet focus, (2) 42-inch Clark reflecting telescope, (3) a new 13-inch photographic telescope, (4) 15-inch Petit-didier reflector, and in addition several smaller instruments, together with a number of spectrographs, special cameras for photographing the planets, radiometric apparatus for use with the 42-inch reflector, for measuring the heat of the planets, and such laboratory equipment as is needed in the work carried on.

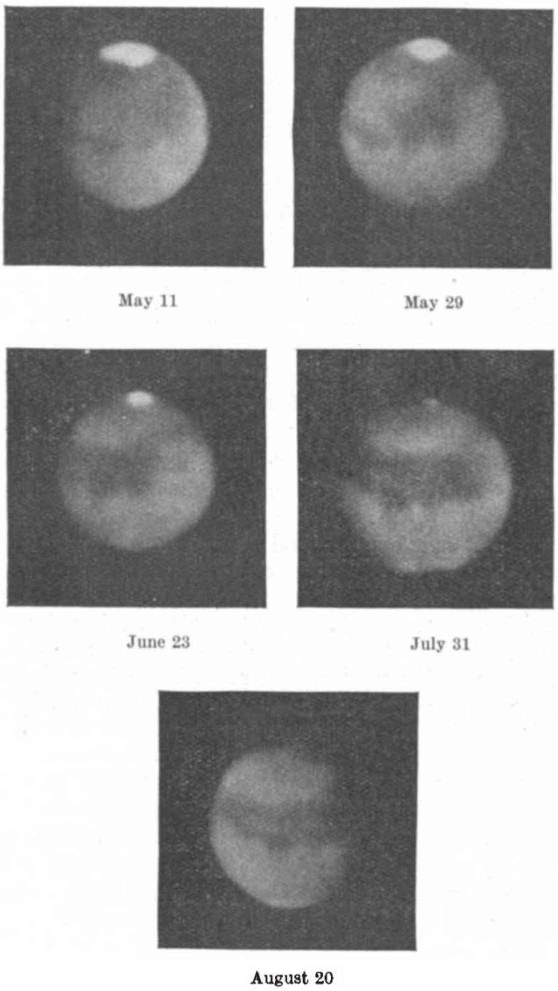


FIG. 1.—Photographs of Mars showing the shrinking of the polar cap and the growth of dark areas.

During the first decade, the work at the Observatory was mainly visual observations of the planets, then it was extended to include their spectrographic study, and during the second decade direct photography of the planets was added and has been continued since, giving a permanent record of them to the present time. During the past decade, their heat measurement has also been made a regular part of the observational programme. In short, whenever it has been possible to apply new means, they have been made use of in order that the planets be studied from every possible point of view.

During the early years of the Observatory, Lowell was able to observe Mercury and to confirm Schiaparelli's conclusion that the planet constantly keeps its same face to the sun, as our moon does to the earth. Thus its small mass and the intense heating by the sun long since dissipated its atmosphere. Venus proved more difficult, and with very faint surface markings, its length of day was left somewhat uncertain, while from all considerations it appeared that this planet also keeps the same face constantly toward the sun, for even the spectrograph showed no evidence of a day shorter than a few weeks. Spectral studies of Venus have failed to give any evidence of an earth-like atmosphere, no bands of oxygen or water being found, although it might have been expected that Venus would be the planet most like the earth.

From this non-committal and veiled planet we pass to the best observed of all, Mars, which has long attracted wide interest. Martian seasonal change shows itself clearly in the polar caps, which alternately increase and decrease, and in the blue-green markings which darken in the growing season and pale again as winter approaches, the great ochreish expanses, changing little from winter to summer, except as influenced by light spots and clouds. The shrinking of the polar cap with summer's coming is to be seen in Fig. 1, where are shown five photographs of the same face of the planet showing particularly the upper hemisphere, but made at Martian seasonal dates. With the contraction of the cap the shaded areas darken and enlarge, as may readily be seen in the photographs.

Dark rifts appear in the melting caps, always at precisely the same time and the same places each Martian year, which clearly prove the caps to be deposits on the planet's surface. Irregularities of the surface must cause this patchy melting of the caps to be repeated always with most punctual harmony to the Martian calendar. Such features of the melting caps are to be seen in Fig. 1. The

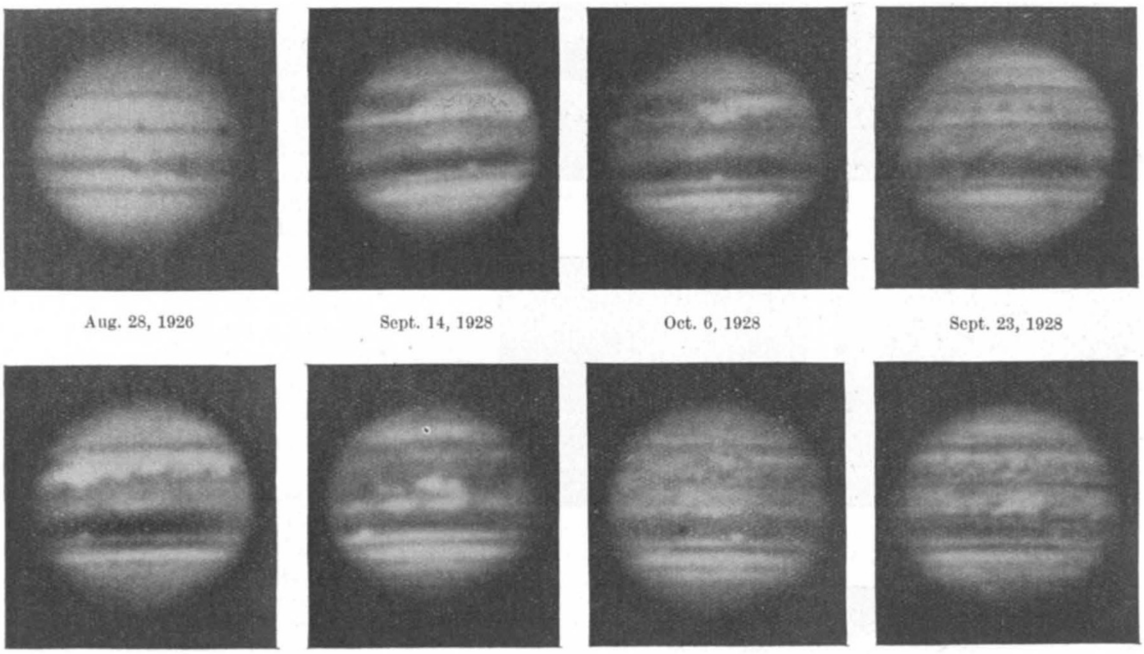
* From a discourse entitled "Planet Studies at the Lowell Observatory", delivered at the Royal Institution on Friday, May 19.

melting cap is bordered by a dark collar, and is more disposed to be regular in outline than the forming cap, which is irregular in outline and indefinite, and to begin with is erratic storm clouds only. An autumn cap appears at the opposite side of the planet to the polar cap.

The behaviour of the caps means that Mars has an atmosphere, for that is the only vehicle which does such transportation of substance. Occasionally, when Mars is so placed that we look a little into its night sky, we see on it a bright streak of light due to a cloud high in its atmosphere, catching the sunlight, while the surface is dark beneath it. Such allow us to measure their height above the Martian surface, and a fine one in 1903 was fully 15 miles high, whereas clouds are rarely more than 5 miles above the earth. Hence Mars must have quite a considerable atmosphere, and the spectrograph at Flagstaff showed it to contain water and oxygen, but no strange substances. Thus it closely resembles that of the earth, but is less dense, because the Martian surface gravity is only three-eighths of ours. There is, therefore, good proof that the polar caps of Mars are snow. Long ago someone suggested they might be frozen carbonic acid gas, but Faraday himself showed experimentally the conditions of pressure and temperature required to solidify this gas; conditions which we are sure cannot prevail on Mars.

Lowell, some years ago, deduced the temperature of Mars from a full evaluation of the factors involved, such as albedo, the behaviour of the caps, etc., and arrived at a value of 48° F. This has recently been confirmed by the radiometric measurements made at Lowell Observatory by Coblentz and Lampland.

While there is room for difference of opinion as to the interpretation of the canals of Mars, their existence as true markings on the planet has been clearly established, for they have been photographed and have been seen by nearly all skilled observers who have observed the planet carefully with powerful instruments. The Lick astronomers Schaeberle, Campbell and Hussey of the early observers, and Trumpler more recently, all drew the canals. Because changes take place in the planet's features in quite short time intervals sometimes, observers may seem to disagree and yet both be right.



Aug. 28, 1926 — Sept. 14, 1928 — Oct. 6, 1928 — Sept. 23, 1928

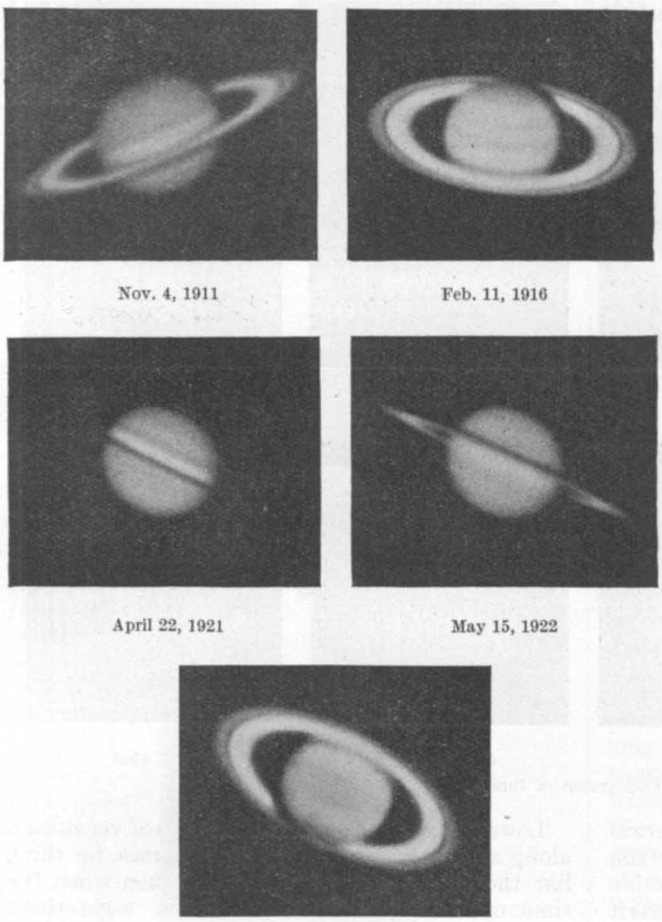
Sept. 22, 1928 — Nov. 30, 1928 — Oct. 6, 1928 — Oct. 7, 1928

FIG. 2. Photographs of Jupiter.

Lowell regarded the canals as strips of vegetation along artificially produced water courses, for they, like the larger blue-green areas, darken when the time comes for seasonal growth in vegetation; and this led to the belief that vegetable life, and hence also probably animal life of some degree of intelligence, exist on Mars.

Jupiter has received much study at the Lowell Observatory. What we see on Jupiter are mostly atmospheric features, apparently nothing of a solid surface appearing. Usually so much detail is present that the visual observer, owing to the planet's rapid rotation, has difficulty in recording properly in drawings and notes all he is able to see under good observing conditions. In these circumstances the aid of photography has been very important, and a photographic record of the planet, as complete as possible, has been kept at Flagstaff since 1905. Fig. 2 indicates the nature of the Jupiter markings and gives some idea of their rapid and sometimes extensive changes, which give some hint of the very great activity present on the planet.

Spectrum analysis of the light of Jupiter has revealed a great number of dark bands in the red and infra-red, due to the selective absorption of its atmosphere. Most of these are yet unidentified, but ammonia is present, and possibly also methane gas. The most remarkable quality of the planet's atmosphere is its rapidly increasing absorption into the longest wave-lengths, which must affect the radiation in a decided manner.



Nov. 4, 1911 — Feb. 11, 1916 — April 22, 1921 — May 15, 1922 — Sept. 2, 1929

FIG. 3. Photographs of Saturn.

Saturn has been regularly observed at Flagstaff, visually, photographically, and spectrographically. Lowell studied theoretically the planet's law of mass distribution, the polar flattening and relation of satellites to divisions in the ring system, leading to new results. Photographs of the planet and rings in light of different colours show some surprising changes, sometimes from year to year. It was found in 1921, when the earth and sun were very near the plane of Saturn's rings, that, contrary to previous belief, the rings could always be seen, and that the rings caused two dark lines across Saturn's ball, one the shadow of the rings and the other the rings themselves as seen dark against Saturn (Fig. 3).

Spectrum analysis of Saturn's light shows much the same absorption bands as were found for Jupiter (except that those of ammonia are weaker in Saturn), so their atmospheres are much alike. The rings show no atmosphere, but are meteoric. The fact that the cloud belts of Saturn are so much weaker than those of Jupiter is doubtless due to the former having a very great seasonal disturbance owing to its highly tipped axis. This factor is practically absent from Jupiter, and so allows its clouds to form and continue strongly belted parallel to the equator, whereas for Saturn the seasonal disturbance tends to destroy such belts.

While Uranus and Neptune are each more than sixty times the volume of the earth, their great distances, nineteen and thirty times our distance from the sun, give them only tiny discs even in the largest telescopes, and markings on them are very difficult of observation. Hence to get the rotation of Uranus the spectrograph was employed; it showed the planet's day to be 10·7 hours, and the rotation to be in the direction in which the satellites revolve.

The spectrum analysis of these two planets has also taught us much as to their atmospheres. They bear resemblance to those of Jupiter and Saturn, but show much more intense and numerous absorption bands, the strongest of which are present in the two latter planets. This atmospheric band system is much more intense in Neptune than in Uranus; in short, the bands increase from Jupiter to Uranus and again from the latter to Neptune, somewhat with the distance of the planet from the sun.

Fig. 4 shows the spectra of these four planets compared with that of the moon, and gives a good idea of the manner in which the absorption bands increase from Jupiter to Neptune. It is of interest to note that the ammonia band clearly evident in Jupiter, a little way to the left of C, is weak in Saturn, Uranus and also in Neptune.

This study of the planets at the Lowell Observatory, in addition to many results not given here relative to the several planets, has much emphasised the differences of the two main groups of planets: Earth, Venus, Mercury and Mars, and the giant group—Jupiter, Saturn, Uranus and Neptune. The first group are comparable with the earth in size, in density, in energy they receive from the sun and in atmospheres, so far as they show any at all. The other group are much larger bodies, but of much lower densities, and have a very different type of atmosphere, while the solar energy they receive is much less than the earth's share—ranging from 1/26 for Jupiter to 1/900 for Neptune. But these studies indicate that these planets may be much more effectively utilising this small energy gift from the sun than does the nearer group of planets, for their atmospheres, as their spectra show, are as blankets retaining energy of the longer heat-waves, and may let little or none pass out in the heat spectrum available to observers on the earth.

These studies further direct attention to that important break between the two groups of planets between Mars and Jupiter, and emphasise the need of its further study, and perhaps from theoretical grounds as well, for when we know what has happened to produce the asteroids and cause this vast change in the planetary bodies, we shall better understand the past of the solar system.

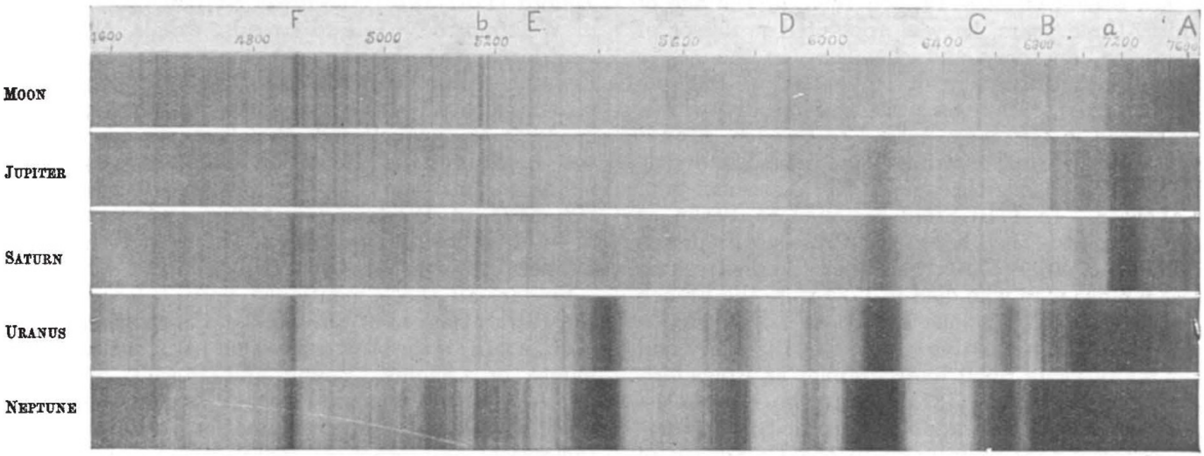


FIG. 4. Spectra of planets and the moon.

Scientific Centenaries in 1934

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THE records of the past year contain accounts of many commemorations of the centenaries of notable men such as Wren, Pepys, Priestley and Trevithick. In some instances the celebrations included the arrangement of interesting exhibitions, the delivery of lectures and the erection of memorials, but in every case they reminded the world of its benefactors and brought to light new information regarding the lives and work of those commemorated. If the sole value of the practice of commemorating centenaries were that it reminded us of great achievements it would be justified, for most men are like Emerson who said: "I cannot even hear of personal vigour of any kind, great power of performance, without fresh resolution." Then, too, we are all debtors of the dead, appropriating from their labours what is pure grain, rejecting what has proved to be chaff and utilising their discoveries and inventions for furthering our immediate ends.

In looking forward once again, it will be found that the centenaries falling within 1934 recall names worthy in every way to be placed beside those brought to mind during the past year. In their own time, and in their particular spheres of activity, few men held higher positions among their fellows than Mendeléeff, Langley, Weismann, and Haeckel, who were all born a century ago, or Jacquard and Telford, who died in 1834. But they only built on the work of their predecessors, and in commencing a short review of the scientific centenaries of 1934, it is of interest to go back to the revival of learning and the days of the Reformation. The outstanding figure in the science of those days was Copernicus (1473–1543), one of whose contemporaries was Otto Brunfels, who died on November 23, 1534, four centuries ago. The son of a German cooper, Brunfels was in turn a Carthusian monk, a Lutheran preacher, a schoolmaster at Strasbourg and a doctor in Berne. His study of herbs caused him to be called a reviver of botany and his name was afterwards given to a genus of plants by Plumier. The year of Brunfels's death saw the birth of another German botanist, Joachim Camerarius (1534–98), son of the learned scholar who reformed the University of Leipzig. The pupil of Melancthon, Camerarius received the degree of M.D. at Bologna in 1562, then settled in Nuremberg and there formed one of the earliest botanical gardens. A French botanist of a hundred years later was Denis Dodart (1634–1707), physician to Louis XIV, a member of the Paris Academy of Sciences and one of the compilers of the "Mémoires pour servir à l'histoire des plantes" published in 1676.

It was but natural that the early botanists should be recruited from the ranks of the