ASTRONOMY

The Moons of Mars

"A Classic of Science"

Two Satellites of "The Moonless Planet" Discovered by Asaph Hall and Named for the Steeds of the God of War

OBSERVATIONS AND ORBITS OF THE SATELLITES OF MARS. With Data for Ephemerides in 1879. By Asaph Hall. Washington: Government Printing Office, 1878.

IN THE SPRING of 1877, the approaching favorable opposition of the planet Mars attracted my attention, and the idea occurred to me of making a careful search with our large Clark refractor for a satellite of this planet. An examination of the literature of the planet showed, however, such a mass of observations of various kinds, made by the most experienced and skillful astronomers, that the chance of finding a satellite appeared to be very slight, so that I might have abandoned the search had it not been for the encouragement of my wife. A more complete examination of the observations also gave some encouragement, as it showed that hardly any astronomer since the time of Sir William Herschel had made a special search for satellites. It is evident from his notes that Herschel was searching for satellites in 1783, and his failure to find any seems to have convinced astronomers that none existed; and the statement that "Mars has no moon" became current in our textbooks. The only astronomer of recent times whose doubt of the prevailing opinion was strong enough to induce him to make a thorough search for a satellite was Professor D'Arrest, formerly Director of the Observatory at Copenhagen. A reference to D'Arrest's search is made by Dr. Klein in his *Handbook of Astronomy,* vol. I, p. 140; and a more complete statement is given by D'Arrest himself in the *Astronomische Nachrichten,* vol. 64, p. 74. I inferred that D'Arrest made his search during the favorable opposition of Mars in 1862, but I am not certain that this was really the case, and perhaps D'Arrest missed the favorable opportunity; and did not make his search until 1864. D'Arrest died in June, 1875; but through the kindness of Professor Schjellerup, the present Director of the Observatory at Copenhagen, I learned that D'Arrest's handbook shows that he made an earnest search for satellites, but failed to find any. In his statement in the *Astronomische Nachrichten,* D'Arrest assumes a distance of Mars from the earth equal to 0.52, and with an assumed value of the mass of the planet he computes the apparent elongation of a satellite that would revolve around the planet in a given number of days. He shows that a satellite at an elongation of 70′ would have a period greater than the period of Mars around the sun, or greater than 687 days, and hence infers that it is useless to search beyond the distance of 70′. The fact that D'Arrest, who was a skillful astronomer, had searched in vain was discouraging; but remembering the power and excellence of our glass, there seemed to be a little hope left. The southern declination of the planet in the opposition of 1877 was, however, against us, and the chances seemed to be in favor of the powerful reflector at Melbourne.

Found Nothing

My search for a satellite was begun early in August, as soon as the geocentric motion of the planet made the detection of a satellite easy. At first, my attention was directed to faint objects at some distance from the planet; but all these proving to be fixed stars, on August 10 I began to examine the region close to the planet, and within the glare of light that surrounded it. This was done by sliding the eye-piece so as to keep the planet just outside the field of view, and then turning the eyepiece in order to pass completely around the planet. On this night I found nothing. The image of the planet was very blazing and unsteady, and the satellites being at that time near the planet, I did not see them. The sweep around the planet was repeated several times on the night of the 11th, and at half past two o'clock I found a faint object on the following side and a little north of the planet, which afterward proved to be the outer satellite. I had hardly time to secure an observation of its position when fog from the Potomac River stopped the work. Cloudy weather intervened for several days. On the night of August 15, the sky cleared up at eleven o'clock and the search was resumed; but the atmosphere was in a very bad condition, and nothing was seen of the object, which we now know was at that time so near the planet as to be invisible. On August 16, the object was found again on the following side of the planet, and the observations of that night showed that it was moving with the planet, and, if a satellite, was near one of its elongations. On August 17, while waiting and watching for the outer satellite, I discovered the inner one. The observations of the 17th and 18th put beyond doubt the character of these objects, and the discovery was publicly announced by Admiral Rodgers. Still, for several days the inner moon was a puzzle.

ASAPH HALL

Professor of Mathematics, U. S. Navy, who discovered the two satellites of Mars at the close approach of that planet to the earth in 1877. He used the 26-inch telescope at the U. S. Naval Observatory, at that time one of the largest telescopes in the world.

It would appear on different sides of the planet in the same night, and at first I thought there were two or three inner moons, since it seemed to me at that time very improbable that a satellite should revolve around its primary in less time than that in which the primary rotates. To decide this point I watched this moon throughout the night of August 20 and 21, and saw that there was in fact but one inner moon, which made its revolution around the primary in less than one-third the time of the primary's rotation, a case unique in our solar system.

Names of the Satellites

Of the various names that have been proposed for these satellites, I have chosen those suggested by Mr. Madan of Eton, England, viz:

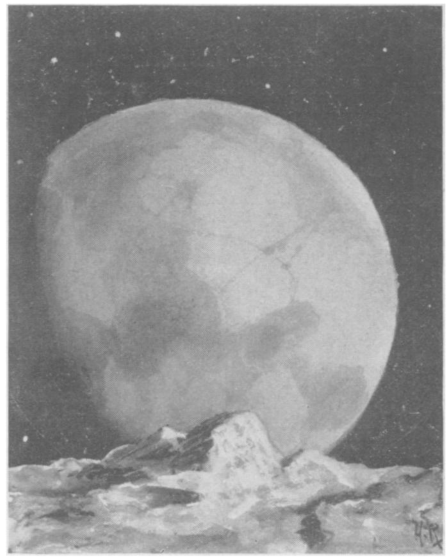
DEIMOS for the outer satellite;
PHOBOS for the inner satellite.

These are generally the names of the horses that drew the chariot of Mars; but in the lines referred to they are personified by Homer, and mean the attendants, or sons of Mars. These lines occur in the Fifteenth Book of the Iliad, where Ares is preparing to descend to the earth to avenge the death of his son. Bryant's translation is as follows:

"He spake, and summoned Fear and Flight to yoke.
His steeds, and put his glorious armor on."

The Washington observations of Deimos extend from August 11 until October 31, and those of Phobos from August 17 until October 15. Both satellites were observed at the Harvard College Observatory by Mr. Leonard Waldo with the 15-inch Munich refractor; and a good series of observations of both these faint moons was made by Mr. Henry S. Pritchett at Glasgow, Missouri, with the 12¼-inch Clark refractor of the Morrison Observatory. Observations of Deimos were made at several observatories in Europe: Pulkowa, Greenwich, Oxford, and Paris; and at the private observatories of Mr. Common in England and Mr. Erck in Ireland. But, so far as I know, Phobos, the inner moon, which is the brighter one, but more difficult to observe on account of its proximity to the planet, was not observed in Europe except at Greenwich and Oxford. As this moon was observed by Mr. Pritchett very near the limb of the planet with a 12¼-inch Clark glass, and was seen on several nights by Dr. Draper and Professor Holden with the 12-inch Clark glass belonging to Dr. Draper, I think the observers in Europe failed to find this moon because they did not keep up a careful and persistent search for it. Its motion is very rapid, and for a considerable part of the time it was hid by the planet. It is so close to the planet that it is a difficult object, but that it is brighter than Deimos is shown by the fact that it could be followed and observed much nearer the limb of the planet. The northern position of the European observatories would increase the difficulty of finding such faint objects, and perhaps also the inferior definition of some of the European telescopes is another reason why observers there failed to find this inner moon.

Since the series of observations at Washington is much more complete than any other, I have decided to use these alone for computing the orbits of the satellites; and afterward to compare with the resulting elements all the other observations, and to deduce from each set the correction to the mean distance of the satellite, which is the most interesting and important element. As the satellites were always in the glare of light that surrounded the planet and were faint objects, the observations were made with difficulty, and probably each observer has a constant error, which would make it difficult and unwise to unite all the observations into one mass. My own observations were made by laying the wire of the filar micrometer across the disk of the planet so as to divide this disk into two parts of equal area, as nearly as the eye could estimate, and then bisecting the satellite. On a few of the finer nights, the observation could be made with Mars in the field of view; but generally it was necessary, in order to bisect the satellite, to slide the planet out of the field. In this case, the eye-piece was slid backward and forward, and the wire of the micrometer was moved until the



(American Museum of Natural History)

A CLOSE-UP OF MARS
From the satellite, Phobos, as the artist, Howard Russell Butler, imagines it.

bisections remained satisfactory. In the case of so large a disk as that of Mars, it would perhaps be better to insert a pair of wires that would cut off small equal segments on each side of the planet; but some of the observations were already made, and I disliked to break the continuity of my work, and experience has given me confidence in the method used. The observation of Professor Newcomb on August 18 was made in the same manner as my own; that of Professor Harkness, of the same date, by measuring from the limbs of the planet; and the observation of Professor Holden on September 23 was a measurement of the differences of right ascension and declination with the filar micrometer. The eye-piece was an achromatic one, giving a magnifying power of 400. . .

Motion of the Satellites

The elements of the orbits of these satellites show that they both move very nearly in the plane of the equator of Mars, and the peculiarities of their areocentric motions will be readily deduced from these elements. The hourly areocentric motion of Phobos is 47°.033; and on account of its rapid motion, and its nearness to the planet, this satellite will present a very singular appearance to an observer on Mars. It will rise in the west and set in the east, and will meet and pass the outer moon, whose hourly motion is only 11°.882. The distances of these satellites from the centre of the planet are: for Deimos

14,500 miles, and for Phobos 5,800 miles. The semi-diameter of the planet being 2,100 miles, the horizontal parallaxes of these satellites are very large, amounting to 21° for Phobos. The nearness of this satellite to the surface of the planet will produce apparent eccentricities in its motion, and cause it to appear as a variable star.

The size of the satellites is not well known, and perhaps the only thing we can say in this respect is the indefinite statement that they are very small. A photometric determination of their size was made by Professor Pickering, Director of the Harvard College Observatory. Professor Pickering's observations are not yet published, but I understand that his result is that the diameter of Deimos is 6 miles, and that of Phobos 7 miles. Mr. Wentworth Erck of Ireland also made a photometric determination of the diameter of Deimos, and found this diameter to be 14 miles. Mr. Erck's account of his determination is published in the *Astronomical Register* for January, 1878. Such determinations are, I think, subject to a considerable degree of uncertainty; but Mr. Erck's method gives us the means of estimating with tolerable accuracy the apparent telescopic brightness of these satellites. My own estimates of magnitudes having become uncertain by using the 26-inch refractor, Professor Eastman and his assistants, Messrs. Frisby, Skinner, and Paul, have made estimates of the magnitude of the star compared with the outer satellite on August 17, using for this purpose the 9½-inch equatorial; and from these estimates I infer that Deimos at the opposition, and at its elongation was of the 12th magnitude of Argelander's scale.

Science News Letter, August 15, 1931

MARINE BIOLOGY

Oysters Will Be Planted And "Reaped" Annually

THE SOW-AND-REAP method so common to agriculture is on trial in the oyster industry. An enterprising company operating at Padilla Bay on Puget Sound will plant seed oysters from Japan about the first of each year and harvest them the following fall.

Fifty million oysters are now growing in the Padilla beds and will be ready for cocktails before long. Care will be taken not to let the oysters reach the gigantic, "beefsteak" size they would if allowed to attain their full growth.

Science News Letter, August 15, 1931

BOTANY-MEDICINE

Ragweed Cause of Hay Fever Suffering in Late Summer

LATE summer, bringing the main hay fever season, is upon us. The air is filled with the invisible plague of floating pollen, tormenting sensitive noses and starting thunderstorms of sneezes and torrents of irrepressible tears.

Why should hay fever rise to such a crescendo just about now, and hold its evil spell upon so many suffering mortals for the next month or so?

The answer is found in one word: Ragweed.

For some reason as yet unknown, more persons are sensitive to the pollen of the two principal species of ragweed, the tall and the low, than to any of the many other pollens that can and do cause hay fever suffering in others.

Between the two evil weeds it is hard to choose the worse. But perhaps the tall ragweed, because of its lustier growth and its distribution, at least as widespread as that of its low cousin, loads the air with more pollen and is therefore the more accursed.

The tall ragweed would be not such an ill plant to see, if one did not know its despicable character. To be sure, it has no gaudy bloom, like that impudent vegetable tramp the jimsonweed; but at any rate it is tall and straight, reaching heights of from six to sixteen feet, and it masses into dense, jungly growths on rich lands left fallow, particularly on often-flooded river-bottoms. The fact that it is an annual, sprouting anew each year from last year's abundant seed, makes it particularly well adapted for the quick conquest of such places.

When the tall ragweed begins to shed its pollen, the low ragweed picks about the same time to add its quota of sneeze-provoking dust.

The low ragweed is a lesser plant than the tall, though not much if at all a lesser evil. It seldom lifts its tough, scrawny stems more than three or four feet high, and in much-tramped pastures, which it seems to delight in, it may not be taller than a foot or two. But what it lacks in height it makes up in distribution. Less particular about soil and moisture than its brother pest, the low ragweed grows in thin, dry upland soils as well as in rich bottom lands and between rows in well-watered cornfields.

A bright and lovely wild flower, that has the ill luck to come into bloom con-

GOLDENROD

It starts psychological sneezes, and is unjustly accused of being a real cause of the ailment

TALL RAGWEED

The ragweeds, both tall and low varieties, give more people hay fever than any other plant.