ler conditions of extreme cold do not reflect as much light as those growing in milder climates. Evergreens, for example, were found to reflect about half as much of the red rays in winter as in summer. About half the radiant energy from the sun is contained in the infrared region of the spectrum. Ordinarily, green plants reflect these rays strongly. But in an extremely cold climate the plants protect themselves from the cold by absorbing as much as possible of the radiant energy from the sun. They not only absorb much of the infrared radiation of the sun but a considerable portion of the red, orange, and yellow light as well. Therefore, plants growing in excessively cold climates do not show the characteristic absorption band of chlorophyll in the red simply because the radiation throughout this whole region is absorbed. Plants growing in the Arctic usually appear darker or "bluer" than plants growing in a warmer climate because they reflect principally violet, blue, and green light; whereas plants in warmer climates reflect yellow and some orange. From their observations on the Pamir plateau in the Arctic, the climate of which is hardly less severe than that of Mars, Tikhoff and his colleagues concluded that the low Martian temperatures would not necessarily be fatal to plant life.

From considerations of the maria, Salisbury concluded that life as it is known on earth could not survive the rigours of the Martian climate. But he offered two biological possibilities: that life forms, essentially similar to those known on earth, have become adapted to the planet; or that some other form of life, a parabiology, accounts for the markings on Mars.

Animal Life.—Existence of animal life on Mars is much less likely than plant life. It is unlikely that higher forms of animal life could exist in such a cold, arid, and oxygenless world. Only the lowest types of animals, with little need of oxygen or water, would be able to survive. Information on this point has been obtained experimentally by subjecting terrestrial microorganisms to an environment closely simulating that on Mars (E. Packer, S. Scher, and C. Sagan, 1963). From their results these workers stated their conclusions as follows:

> We may have some confidence that terrestrial microorganisms will survive the inclemency of the Martian environment and that under supercooled conditions at temperatures above −20° C some bacterial growth can be anticipated. Growth will depend in part on the availability of water and organic material on and near the Martian surface. The likelihood that many terrestrial microorganisms can survive on Mars has, of course, no rigorous implications for the likelihood of indigenous life on that planet. Yet it does demonstrate that evolutionary tractable biological mechanisms exist for survival and growth under contemporary Martian conditions, and suggests that organisms slowly evolving from the more clement conditions in the ancient Martian past may have even greater capability for dealing with the apparent rigours of the Martian environment.

Mariner 4 was not designed to secure information regarding life on Mars. On the evidence of the photographs, the question is still open. But the moonlike uneroded aspect of the surface shows that the planet has never had an extensive atmosphere or enough water to form seas and oceans. High forms of animal life could not develop under such unfavourable conditions, but plant life is not ruled out. The seasonal changes in the maria are yet to be explained. The new dark area that developed in the Thoth region between 1952 and 1954 begins to loom as an observation of major importance. Thoth was not a feature barely visible like the canals but was an area about the size of Texas and was easily visible to anyone with a 6-in. telescope.

Human Habitability of Mars.—By careful preparation a man could undoubtedly survive on Mars. But he would be living in a hostile, alien environment where the slightest mishap could be disastrous. Atmospheric pressure at the surface appears to be much lower than was formerly supposed. To carry on respiration a pressure suit and oxygen equipment would be necessary. Many reactions so familiar to man on earth that they are taken as a matter of course would be impossible on Mars or would proceed very slowly. A man out on the open surface could not light his pipe or start a fire. Metal would not rust. Under the reduced pressure water would boil away so rapidly it would be useless for cooking purposes. None of the natural sources of energy, such as coal and oil, is available on Mars. Solar radiation would be weak and undependable. To establish a base on Mars, suitable nuclear reactors would first have to be developed to maintain it.

Because the Martian atmosphere is bombarded continually by the full flux of cosmic rays and full fluxes of solar flare particles, the radioactive products of the disintegrations present differ from those on earth and probably are somewhat more intense relative to the density of the atmosphere. Recent evidence indicates that ultraviolet rays penetrate the Martian atmosphere and reach the planet's surface, thus creating a radiation hazard for man.

SATELLITES

The two moons of Mars were discovered by Asaph Hall of the U.S. Naval Observatory in 1877. That year was especially favourable for such a search, as the planet was within 34,800,000 mi. of earth on Sept. 5, the closest approach in 30 years. Other observers had searched in vain for a satellite of Mars, but Hall believed the new 26-in. refractor of the Naval Observatory should be able to detect a companion of Mars, if one existed.

Table V.—*Satellites of Mars**

	Phobos	Deimos
Discoverer	Asaph Hall	Asaph Hall
Date of discovery	Aug. 17, 1877	Aug. 11, 1877
Distance from centre of Mars (radius of Mars = 1)	2.743	6.891
Distance from centre of Mars	5,820 mi. (9,366 km.)	14,615 mi. (23,520 km.)
Sidereal period	7 hr. 39 min. 13.85 sec.	30 hr. 17 min. 54.87 sec.
Inclination of orbit to equator of Mars	0° 57′	1° 18′
Orbital eccentricity	0.0210	0.0028
Approximate magnitude at mean opposition distance	11	12
Estimated diameter	10 mi. (16 km.)	6 mi. (10 km.)

*These data are taken mostly from the *Explanatory Supplement to the American Ephemeris and Nautical Almanac* (1961).

However, he was almost ready to give up the search as hopeless when he sighted a suspicious object near the planet on the night of Aug. 11. Clouds prevented further observations until Aug. 16, when the object was sighted again and found to be moving at the same rate as Mars, thus establishing its identify as a satellite. The following night Hall found another object closer to the planet than the first one; it moved so rapidly that he thought at first Mars must have several inner moons. By keeping watch continually throughout the nights of Aug. 20–21 he satisfied himself that there was but one inner moon. Hall named the outer satellite Deimos (Terror) and the inner one Phobos (Fear), after the horses that drew the chariot of the war god Mars. The discovery of these satellites was of great practical importance as it enabled astronomers immediately to get an accurate value for the mass of Mars.

Phobos is so near the planet that it revolves around Mars in less than one-third of the rotation period of Mars. To an inhabitant of Mars, Phobos would rise in the west and set in the east, making two apparent rotations in a day. The period of Deimos is six hours longer than a Martian rotation. Its apparent motion around the planet would be so slow that more than two days would elapse between rising and setting, and setting and rising.

Phobos and Deimos are too small to present a disk even in the largest telescopes, and so their diameters cannot be measured directly. However, if an assumption is made about their albedos (overall reflecting power of their surfaces) their diameters can be calculated from their apparent brightness. Thus, if the satellites are assumed to have the same albedo as Mercury, the diameter of Phobos is 10 mi. and that of Deimos is 6 mi. But if it is assumed that they have the same albedo as Mars, the diameter of Phobos is about 8 mi. and of Deimos, 5 mi.

In 1959 I. S. Shklovskiy suggested that Phobos is a hollow sphere, and therefore of artificial origin. This startling hypothesis was made in an attempt to explain the apparent increase in the mean motion of Phobos reported in 1954 by F. J. Kerr and F. L. Whipple. If there is an appreciable Martian atmosphere 3,700 mi. above the surface at the orbit of Phobos, it would be more effective in changing the motion of a body of negligible mean density, such as a thin shell satellite, than a solid body of the same size.

Tentative results obtained by G. F. Schilling (1963) indicate the Martian atmosphere at 3,700 mi. may be of sufficient density to produce the acceleration in the mean motion of a solid satellite.