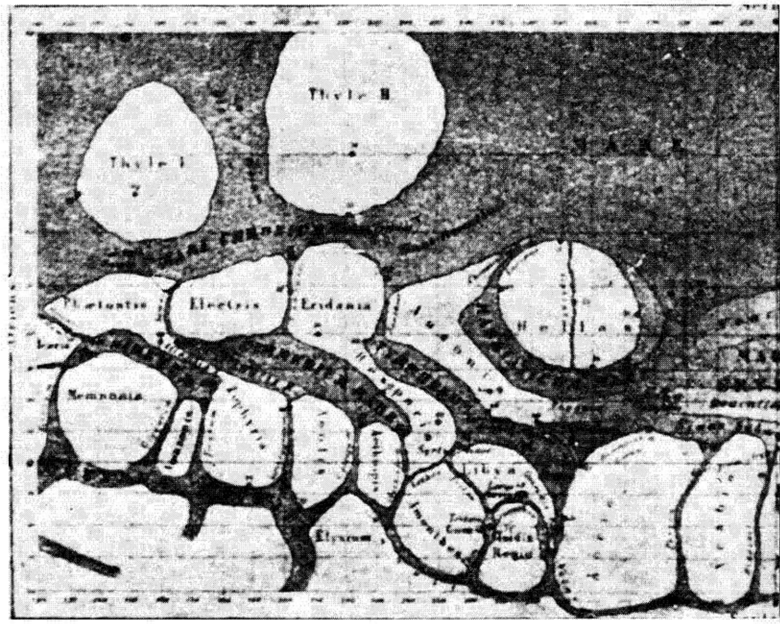
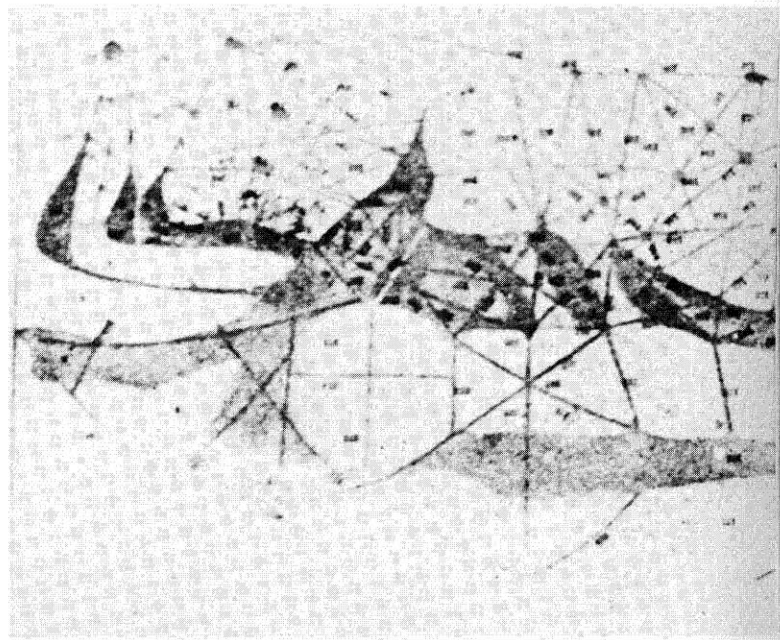
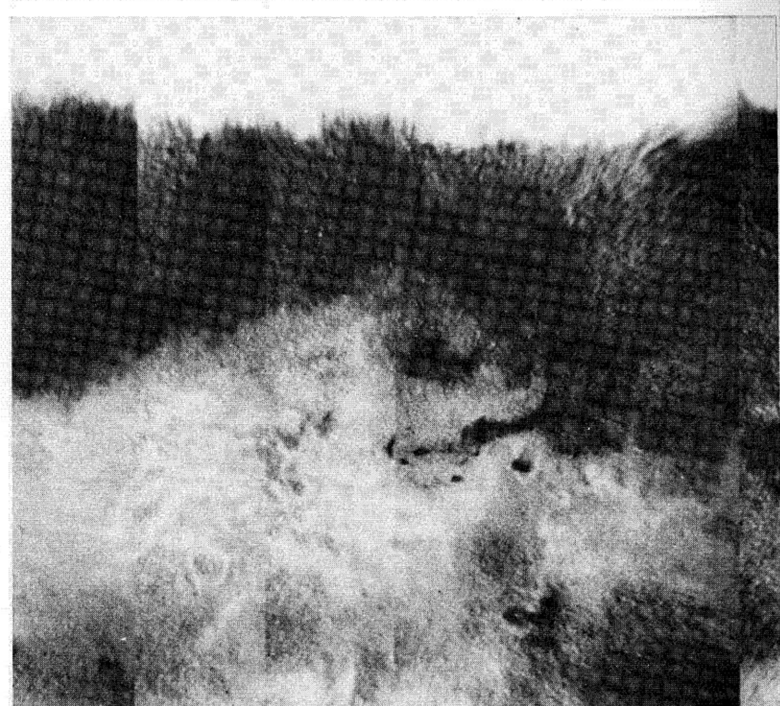
Do the Mariner 9 results increase the possibility that life exists on Mars? No, says Bruce Murray— but Carl Sagan disagrees (p. 16).

Mars: Science Fiction to Science

by Bruce Murray





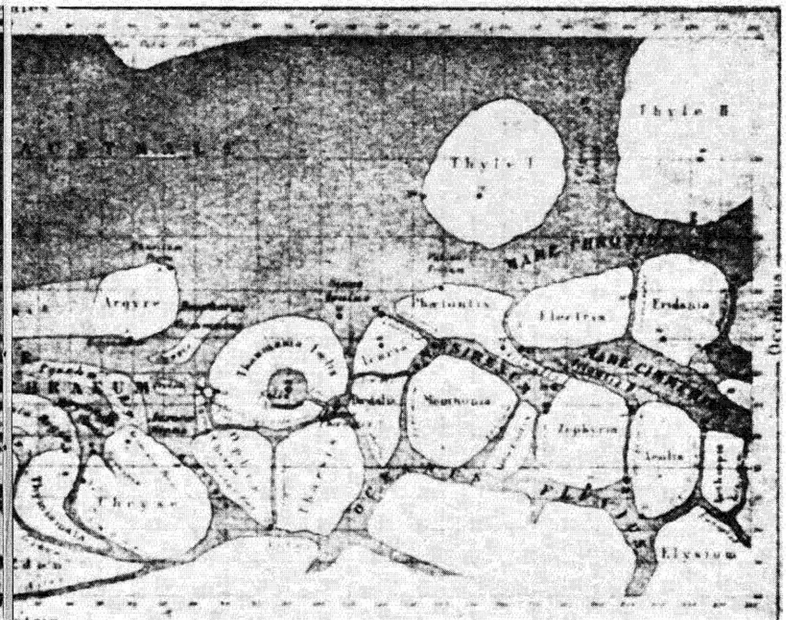


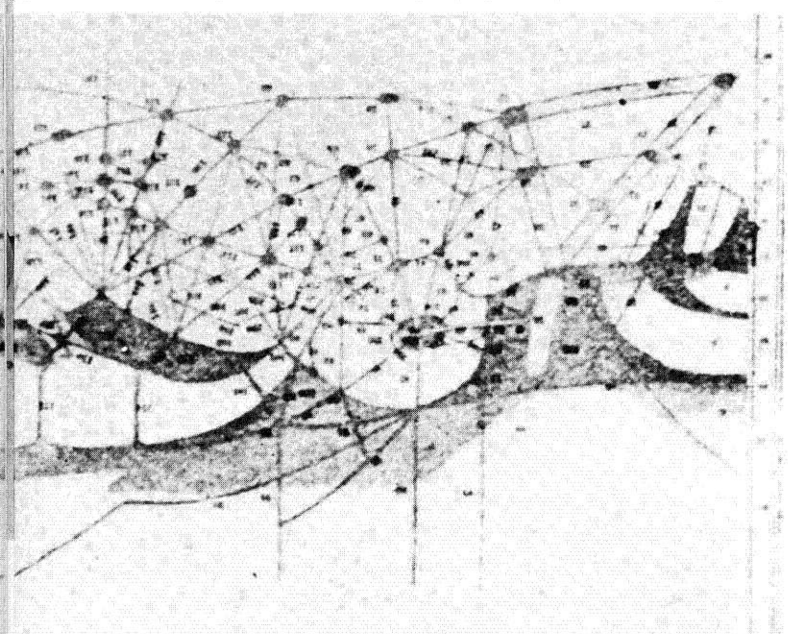
In the last six years Mars has been plucked from the mists of science fiction and scrutinized with the dispassionate eyes of four Mariner spacecraft. As a result, the supposed likeness of Mars to Earth has now nearly vanished. Instead, Mars is now recognized as an independent planetary object, exhibiting on its surface the results of a unique planetary evolution that is still taking place.

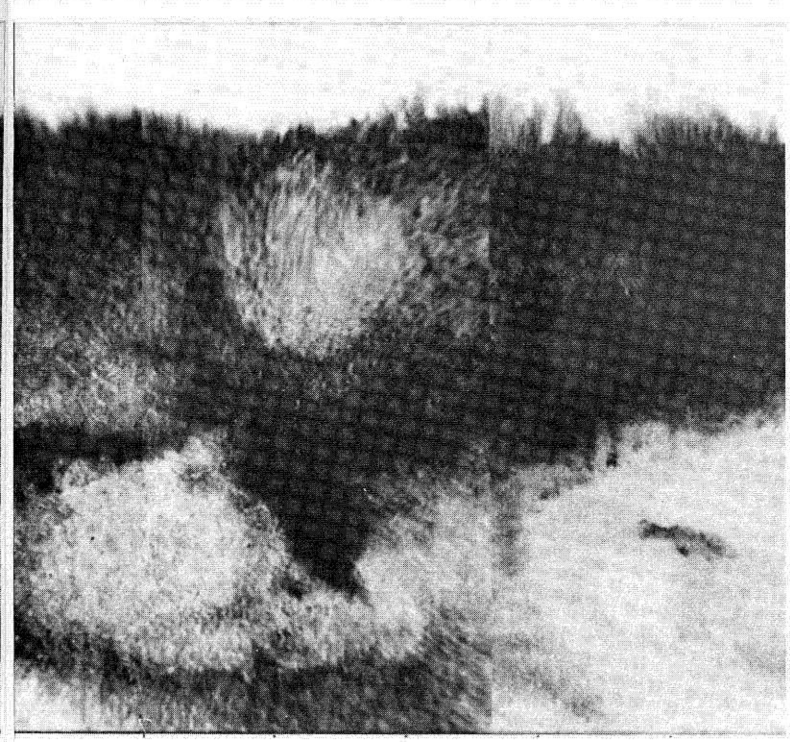
But at the same time Mars is also an interesting sociological study. A look at the history of the observations made of the planet and the conclusions drawn illustrates that scientists, despite all their protestations, are human beings. (It is my feeling that they are perhaps a little *more* human than most people.) They are far from objective about the subjects they study—despite their great attempts to be so—and the study of Mars has been particularly good as an illustration of the difficulty the scientist has in knowing when he has really removed all prejudice from his mind and is dealing only with the observed facts in front of him.

I suggest that we have probably not yet reached that point in regard to Mars.

Throughout recent history, especially from the time of astronomer Percival Lowell in the late 19th century, our observations of Mars have been biased by the belief that the planet was similar to Earth. When we look at a really good, Earth-based telescope photograph of the planet, it is easy to understand why such biases exist. The planet, after all, is not strongly marked. So, if we are really looking for features, we can read almost anything into the the drawings and photographs. Mars varies from a rather dusty orange color to a somewhat darker color that could be taken for green. But there is no true green on the planet at all. There are white polar caps as on Earth. The cap changes in each hemisphere in conjunction with the Martian seasons, just as the Earth's would if viewed from space. Those light and dark markings do change their appearance throughout the Martian year in a sometimes regular, sometimes irregular, pattern. When viewed







through telescopes at the turn of the century, Mars could easily be assumed to be like Earth—and was.

In addition, by a remarkable coincidence, the planet Mars has the same length day as the Earth, to within 35 minutes; and its axis is offset from the plane of the ecliptic by exactly the same amount, 23 degrees.

Given these similarities, it is not hard to imagine why it has been assumed that Mars is like Earth or how this view colored early scientific opinion. To some extent it is still a legacy from the past. I call it "Lowell's Legacy." For it was he who staked the most—and lost the most—on his belief in the Earth-Mars similarity. In fact, he lost his professional reputation as a scientist.

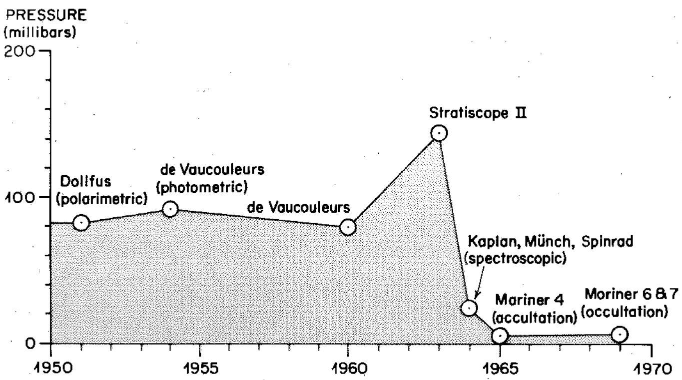
Lowell's classic grandiose book on life on other planets contains a collection of maps done in the period between 1860 and about 1912. Following them in chronological order shows the maps gradually changing in appearance.

One map of Mars drawn by the Italian astronomer Giovanni Schiaparelli in 1877 depicted circular features that show quite accurate observation, but Schiaparelli later attempted to "improve" this map by indicating nice sharp linear features. In the period from 1881 to 1884 the features started getting narrower and more organized. They began to connect, and then finally in 1894, when Lowell came on the scene, they became nice straight lines intersecting at what appear to be nodes of some kind. By 1905 dual canals had appeared in some places on his maps.

This is how the idea of artificial "canals" rather than natural channels or breaks originated. Lowell concluded from his "observations" that the canals intersected at oases. They were, he wrote, canals for transporting water. He believed they were evidence of a dying civilization whose planet, eons ago, was like the Earth. But, being smaller, it lost its atmosphere and most of its water—an idea that was dismissed by most serious scientists at the time. What wasn't dismissed was the idea that plant life might exist there. Rather crude ways of studying the Martian atmosphere existed then, and the results indicated a strong resemblance to the Earth's atmosphere in constituency and pressure.

Lowell's Legacy remained with us even as late as 1969

The features of Mars have not changed drastically in the last 100 years, but astronomers' views have. And not always for the better. Schiaparelli's crude 1877 map (top) is not only more accurate than Lowell's 1894 rendition (center), but even resembles the actual 1969 photomosaic of the same region.



Throughout the 1950's various estimates of the atmospheric pressure on Mars were uniformly an order of magnitude too large—and so did their share to contribute to other erroneous ideas of the planet's similarity to Earth.

(see graph above). In the 1950's it was still believed that plant life of some sort existed on the planet even though a number of techniques had been developed to bring more precision to the study of Mars. Measurements in 1950, 1955, and 1960 cut the estimates of Martian atmospheric pressure down to something like 10 percent of the Earth's at ground level (101.3 millibars). This is roughly equivalent to the air pressure at the top of the Peruvian Andes.

At this pressure—low as it is—many of the conditions present on the Earth might prevail. For example, liquid water could exist on the surface of Mars.

In the early 1960's, however, Guido Münch, professor of astronomy, and two others at the Mt. Wilson Observatory used spectrographic techniques and came up with a figure of about 25 millibars, which is less than 2.5 percent that of Earth's. Finally, in 1965, Mariner 4 yielded a figure of 5 to 8 millibars (about ½ to 1 percent of Earth's pressure). This range was verified by Mariners 6 and 7 in 1969 and by the present Mariner 9. It is obvious now that water cannot exist in the free state on the surface of Mars; there is too great a vacuum. The water evaporates. And therefore the chances of any sort of plant life sufficient to cause surface markings are minimal.

Yet, even as we were getting more precision into our measurements of Mars, Lowell's Legacy persisted. An incident during one of the closest appositions of Mars to Earth in 1956 shows how much we are captives of the past.

Using first a small telescope and then, in 1960, the 200-inch Hale telescope, observations were made of Mars in the invisible wavelengths beyond the red—the infrared—in which plants have characteristic reflections. The compound chlorophyl has an absorption feature in this range that is easy to spot, and absorption features in Mars' spectra in the wavelength region characteristic of chlorophyl were detected. It was concluded that these features were in the spectra from the dark areas on Mars, but not from the light areas. Now, if that were true, it would suggest that there is plant life on Mars in the dark areas and not in the light. If these observations had been made on the Moon, the results would have been checked to see if something wasn't wrong.

As it was later reported, something was indeed wrong. What were actually being observed were the spectral characteristics of HDO, which is similar to the "heavy water" used to make the early atomic bombs. There was no chlorophyl on Mars. However, even after this important discovery was made, the earlier mistake was compounded. It was asked why there was HDO on Mars. The answer would have delighted Lowell: Mars once actually had an ocean and then lost all its water! The heavy-water-like HDO was the enriched fragment that was left over.

Thus, two mistakes in a row were made before the final explanation became clear. The absorption features had nothing to do with Mars. What was being measured was absorption in the Earth's own atmosphere. The original measurements had been made at times when there were slightly different amounts of water vapor—and HDO—in the atmosphere.

Lowell's Legacy persisted even as late as 1969, as an incident related to the Mariner 6 and 7 flights indicates. By that time, because of what we had learned from Mariner 4, we were fairly sure that the north and south Martian frost caps were frozen carbon dioxide—dry ice—rather than water. This was one of the issues Mariners 6 and 7 were to settle. They carried two instruments that could tell us something about that. One was an infrared radiometer to measure temperature. The other was an improved infrared spectrometer similar to the one that led to the spurious identification of vegetation on Mars in the 1950's. The radiometer flying over the caps sent back information suggesting that the surface temperature was very cold—about 150 degrees absolute (or 190 degrees below zero Fahrenheit). This finding supported the idea that the frost was carbon dioxide.

The infrared spectrometer saw some strange features, marked X and Y on the chart to the upper right. These features are about where we would observe methane and ammonia gas in the spectrum if we looked at a mixture in the laboratory. These substances, of course, are by-products produced when living organisms decay, and initially they were interpreted in that sense. It was announced that the white stuff of the polar caps was frozen water and that Mars was a veritable paradise for living things.

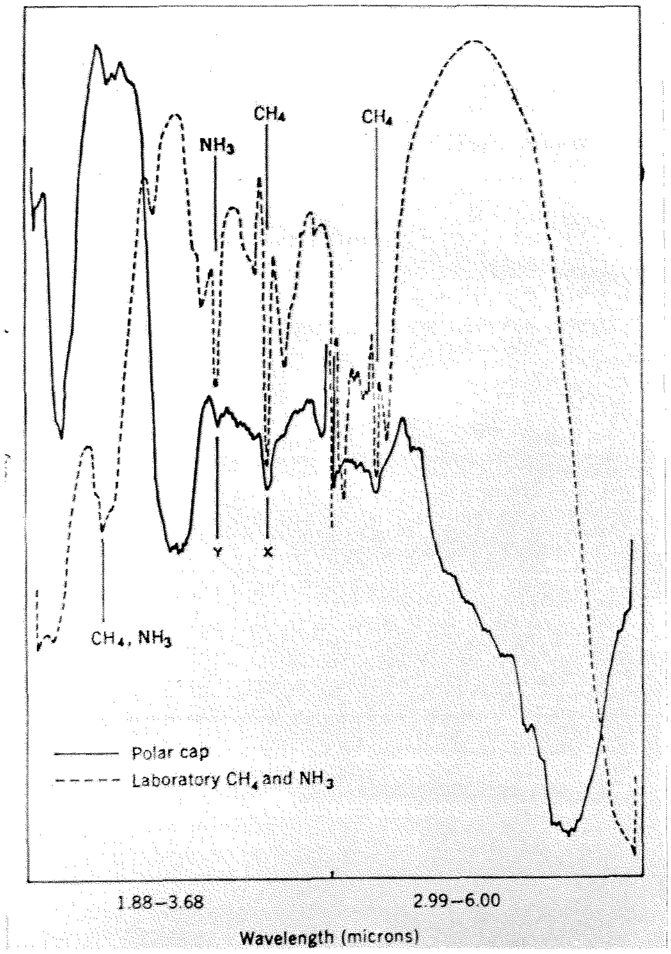
Eventually, with more careful work, it became clear that something else had features X and Y—very, very dry solid carbon dioxide. The spectrometer had not discovered evidence suggestive of life, but of a more hostile environment than had ever been supposed!

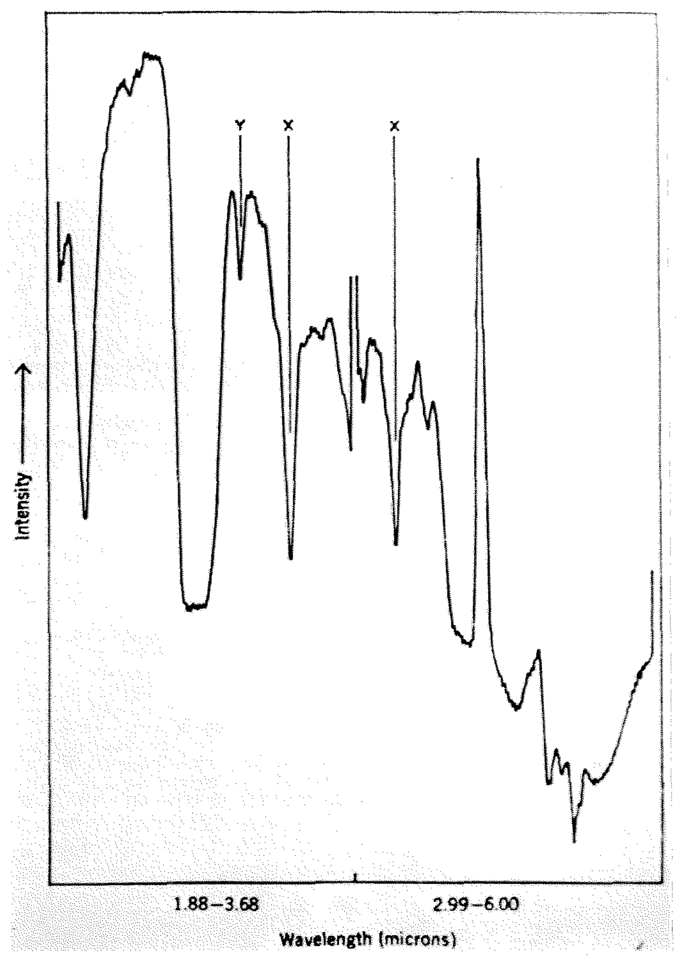
Why were all these mistakes made in favor of the existence of life? Why were pressure measurements estimated high instead of low? Why would a scientist assume he was detecting Martian chlorophyl rather than terrestrial heavy water? Why would someone assume the existence of ammonia and methane in a carbon dioxide atmosphere rather than solid dry ice itself?

The only explanation I can imagine is that those who made such interpretations suffered from the preconceived idea that such evidence of a terrestrial-type environment suitable for plant life might be found.

The results from the current Mariner 9 probe—and to a lesser extent from Mariners 4, 6, and 7—will do much to drive this bias from the minds of most scientists. It is clear that there is little similarity between the Earth and Mars. Some of the planetary processes we have observed bear more resemblance to the Moon. Many, it appears, are uniquely Martian.

The Mariner 4 pictures were stunning in their apparent similarity to the Moon. They showed no mountains like we have on Earth—no folded mountains, no evidence of





The strong similarity of the spectral characteristics of the Martian polar caps (sent back from the Mariner 6 and 7 flights in 1969) and the spectral features of ammonia and methane in a laboratory setting (top) initially led to the conclusion that these two chemicals —which are strongly indicative of life—were present on Mars. Later, more careful analysis, and comparison with the spectra of carbon dioxide (bottom), proved the polar caps were really very dry ice.

These Martian canyonlands are part of a 72,000-square-mile complex photographed by Mariner 9 from a distance of about 5,050 miles. Each of these "Grand Canyons" is about ½ to 1¼ miles deep and 5 miles across with a gentle slope to the bottom. The curving segments of the canyon walls seem to be parts of incomplete craters. Probably the canyons are the result of geological fracturing, followed by sculpturing and erosion of some sort.

oceanic depressions, no signs of island arcs—none of the characteristics of earthly processes. The Martian surface, as far as we could tell from the handful of photographs we obtained, was cratered like that of the Moon. Other instruments indicated that—also like the Moon—Mars has no magnetic field. This means the planet is not shielded from the very intense solar radiation that would be hitting its surface. It suggests that maybe the planet has not boiled and differentiated, which would have given it a core like the Earth's.

Mariners 6 and 7 verified the dry-ice polar caps, the carbon dioxide atmosphere, and the moonlike topography. But they also yielded a couple of surprises. One was a view of jumbled chaotic terrain near the Margaritifer Sinus area. That area, clearly, was not like the Moon. This kind of structure on such a scale was not like anything on the Earth either. It was the first evidence of truly Martian phenomena.

The other surprising area was the circular desert, Hellas, near the equator. This bright region, 1,200 miles wide, is devoid of craters even in the closeup pictures. We are satisfied that the area was not obscured by a dust storm at the time it was photographed, that it is indeed featureless. This indicates that something is either scraping craters away or obscuring them from view. Both areas suggest a current kind of activity. They suggest that Mars is not a completely fossil planet, but an active one—at least in some areas.

The Mariner 9 photographs have been a real shock. We seem to be looking at a different planet from the one we were led to expect by the earlier Mariner results. And, so far, we have only a portion of the 5,000 useful photographs we expect to receive—even though the dust storm during the early weeks of the mission delayed our schedule for receiving them.

One area of cratered terrain photographed by Mariner 9 is totally different from any observed by earlier Mariners (*E&S*, January 1972). These do not appear to be impact craters in any simple way. They are not impact craters that have been modified. They appear to be craters caused by subsidence and collapse as material is withdrawn. This could be due to volcanic activity. The melting of vast quantities of ice beneath the surface of Mars could lead to such features. However, the volcanic origin is the one favored by the photographic team.

An area we call the "Grand Canyon" is spectacular. It consists of a whole series of valleys, each about 5 miles across and 1½ miles deep. The whole area is about 80 miles across. It is a huge feature, comparable in scale to the canyons that break up the Colorado River plateau, including the Grand Canyon. There is widespread evidence of deformation, of things breaking up, of linear features developing. They appear to be relatively uniform plateaus broken up by these huge valleys in an irregular pattern. I don't think they were formed by water. What probably occurred was fracturing to form the breaks, and this was followed by sculpturing and erosion on a grand scale by as yet unknown means. There is nothing on the Moon, there is nothing on the Earth, there is nothing on the earlier Mariner photographs that looks like this.

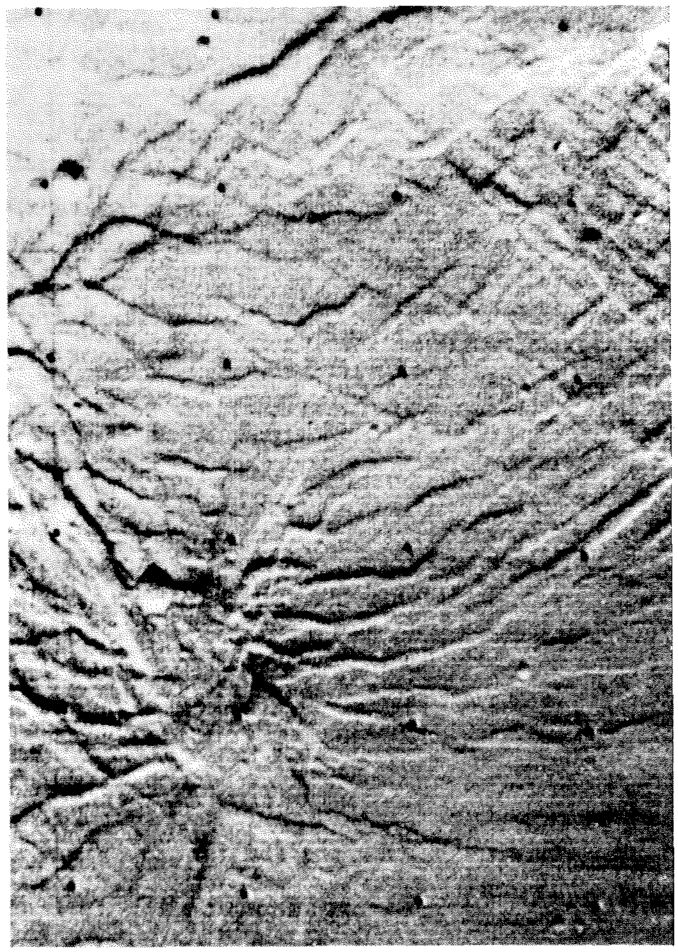
It was a shock. It still is a shock that a planet could be so different.

Another feature, affectionately termed the "elephant hide," looks the way water draining across a tidal flat would look if it were photographed on Earth. Again, this is a large feature: The whole area is about 45 miles across. It is on a plateau about 3½ miles above the mean elevation of Mars. Each fault valley is about 1½ miles across. This too is unlike anything we have seen before.

Mariner 9 found that much of the south temperate zone has irregular light and dark markings not present in Mariner 7 images of the same area taken in 1969. Some of the splotches are contained within craters; others appear to wash over craters. The largest are between 100 and 200 miles across. Mars is alive and well. If it's got a disease, it's measles—or something that makes it look funny. But the planet is very active.

All these photographs indicate that obviously Mars has many different kinds of terrains that reflect a variety of processes, or at least a varying magnitude of processes; and they clearly involve internal activity. And that is something we could never say before.

These Mariner 9 photographs are showing us whole new domains, whole new continents, and we don't really understand yet exactly what they mean. We are still in a state of shock, and it's going to take quite some time for us to digest and react to their real significance.



This "elephant-hide" feature, in the area of Phoenicis Lacus just south of the Martian equator, is a plateau about 3½ miles above the mean elevation of Mars. It was photographed by Mariner 9 from an altitude of 4,000 miles just as the great dust storm was clearing. Scientists believe the area is relatively young geologically, possibly covered by volcanic deposits at one time and later broken into faults that cut the rocks into mosaic-like fragments.

"Mars—Science Fiction to Science" is adapted from a talk given by Bruce Murray for the Caltech Lecture Series at Beckman Auditorium on January 10. Murray, who is professor of planetary science at Caltech, is also one of the co-investigators on the Mariner 9 television team. The View from Space *by Murray and Merton E. Davies (Columbia University Press, 1971) gives further details of the photographic exploration of the planets.*