# LIFE IN THE UNIVERSE

Antonio Lazcano

## Exobiology

The possibility of the existence of extraterrestrial life has disturbed men of science and philosophers since very ancient times. In the 16th century, Giordano Bruno wrote a work in which he stated that the stars were simply other suns, around which revolved planets on which multiple forms of life existed. Bruno's ideas, too advanced for his time, carried him to his death. A victim of religious intolerance and ecclesiastical deceit, in 1600 he was taken to the stake of the Inquisition in Rome.

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Little by little, ideas similar to those of Bruno began to spread among men of science; Kepler, Newton and many others were certain that life existed on other planets. In the majority of cases, however, these ideas were no more than speculations that lacked any scientific basis that could solidly withstand careful criticism.

Arrhenius' theory of panspermia, for example, implicitly includes the notion of extraterrestrial life. Nevertheless, it was not until the formulation of Oparin-Haldane's theory, which satisfactorily explains the origin of living beings on the earth, that men of science had an adequate frame of reference which gave a scientific foundation to the possibility that other forms of life originated and developed in other parts of the Universe.

Scientific study of the possibilities of extraterrestrial life have given origin to exobiology, a discipline that is based on theoretical and observational theories of astronomy, which little by little have demonstrated that the formation of planets and stars similar to the Sun is a relatively frequent event in a galaxy; as well as the analysis of chondritic meteorites and observation of the interstellar medium have demonstrated that organic compounds that determined the appearance of life on Earth are extraordinarily abundant in the Universe and that they constitute a spectacular example of the chemical evolution of matter.

On the other hand, the development of spatial exploration has, for the first time in history, allowed us to have access to other bodies of the Solar system, as well as to directly examine existing conditions on other planets.

The analysis of lunar samples was deceiving in a certain sense; the Moon has

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**Orion. Giant cloud of gas and dust, similar to that which originated our Solar System.** Photo from *El redescubrumiento de la Tierra,* Conacyt.

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turned out to be a body practically lacking atmosphere, in which life never developed and where it has also not been possible to find organic molecules, such as amino acids. The absence of these molecules on the lunar surface is undoubtedly due to the constant bombardment that it suffers from the solar wind, particularly by protons that crash against the Moon's surface at great speeds.

Mercury, the planet closest to the Sun, is also apparently not a very appropriate place for the origin and development of living beings. It posesses an atmosphere of very low density, and the high temperatures on its surface prevent the water found there from maintaining a liquid state. In these conditions it is reasonable to suppose that it is a sterile planet, just as the Moon.

### Venus and Mars

Of all the planets that exist in the Solar System, the most similar to the earth is Venus. The sizes, masses and densities of both planets are very similar; in addition, they are located at distances from the Sun that are in some way comparable.

This similarity of characteristics made some scientists believe that organisms could exist on the surface of Venus; however, the large quantity of clouds that exist in its atmosphere prevent the examination of its surface and this question remained open for a long time, until spatial satellites sent by the United States and the Soviet Union landed on Venus.

The satellites revealed a series of surprising data on the surface conditions of Venus. In the first place, they demonstrated that the surface temperature is approximately 600° K, which confirmed observations that had already been carried out by radio astronomers. Furthermore, it was found that the atmospheric pressure on Venus' surface is close to 100 times greater than that of the Earth, and finally that the chemical composition of its atmosphere is radically different from that of the Earth; carbon dioxide constitutes between 90 and 95% of the atmospheric gases (compared to only around 0.33% of $CO_2$ in the Earth's atmosphere), in addition to containing small quantities of water vapor and some sulphuric acid.

A temperature of 600° K as exists on Venus is capable of melting lead; it is also capable of destroying any cellular system such as those that we know on Earth. Although it has been suggested that perhaps Venus could have had some forms of life on the poles, where temperatures are lower, or else life adapted to live in the upper levels of its atmosphere, these possibilities are highly disputable and the most certain is that Venus lacks life forms.

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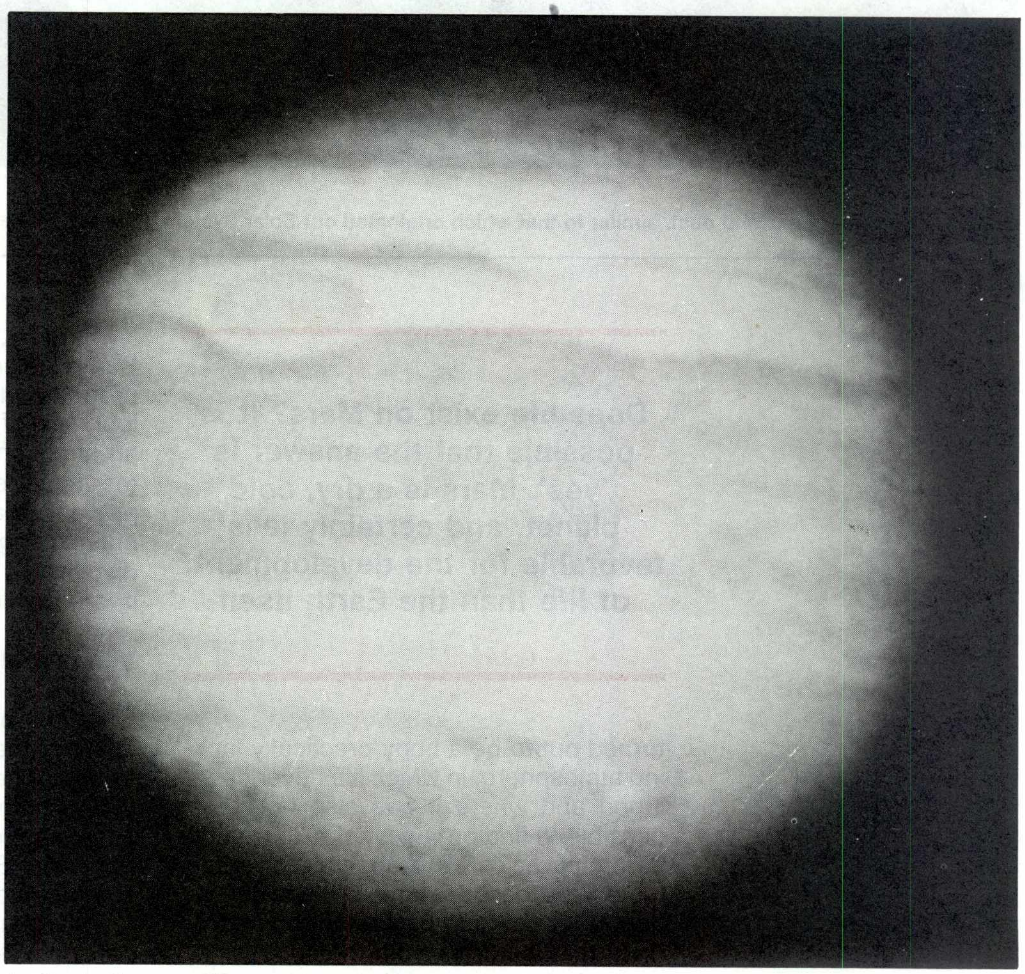


**Jupiter in the eye of Voyager I.** Photo from *El redescubrimiento de la Tierra,* Conacyt.

Mars, in contrast, is a planet further away than the Earth from the Sun. Although its radius is close to half that of the Earth's its density is approximately the same as that of our planet. On the other hand, Mars has an inclination of 24° from its rotational axis with respect to the plane of its orbit, which results in the existence of annual seasons.

During these seasons, it is possible to perceive changes in the polar caps, which advance toward the equator of Mars during the winter and retrocede during the summer. These caps are made of water, covered by a layer of solid $CO_2$. During the spring it is possible to note changes in coloration, that for some time were believed to have been due to the possible development of forms of vegetation and that now it is known are the result of chemical changes in the components of the Martian soil.

The atmosphere of Mars is very thin; artificial satellites that have explored this planet reveal that at ground level its density is very low, compared with that of the Earth. Among the gases that form its atmosphere are above all $CO_2$, but small quantities of ozone, water vapor and nitrogen also exist, together with miniscule quantities of other elements, such as argon.

For some time it was believed that the surface of Mars was literally covered by a multitude of canals, and there were many people who attributed their supposed existence to intelligent forms of life. Although this turned out to be false, photographs of Mars taken from artificial satellites that have orbited around that planet have revealed the existence of what seem to be dry river and stream beds, and that these were perhaps formed by liquid water.

Does life exist on Mars? This is a question that has been asked repeatedly. It is possible that the answer is 'yes'. Mars is a dry, cold planet, and certainly less favorable for the development of life than the Earth itself. Nevertheless, many experiments demonstrate that different forms of vegetal life such as lichens, mosses and different types of microorganisms could survive in similar conditions to those existing on the surface of Mars, which are simulated in laboratories.

# GALILEO GALILEI AND GIORDANO BRUNO AND THEIR IDEA OF SCIENCE

Rocio Alatorre

The figure of Galileo Galilei is of capital importance not only for his discoveries and contributions in the study of physics, but because he set the bases of the concept of "science", and it was due to him that the concept of "experimental method" was born.(1)

Galileo put a stamp on scientific activity, that of experimentation, which decisively marked the ideology which would later dominate in scientific development. There was a important event before the time of Galileo: the so-called "Copernican Revolution" during the Renaissance. Nicholas Copernico, in his book *De Revolutionibus Orbium Coelestium*, published in the year of his death, 1543, proposed a system of spheres revolving around the Sun, not around the Earth, as had been conceptualized up till that time, thus introducing the idea that our planet rotated and demostrating that this new system could explain numerous astronomical observations.

The implications of this revolution took time to infiltrate the consciousness of that era, but little by little they were taken up by various philosophers and astronomers, including Giordano Bruno who, inspired by the new helio-centric system, conceived the idea of an infinite and open universe.

Bruno and Galileo became spokesmen of Copernico's ideas; Galileo has been rendered justice by history, but this is not the case with Giordano Bruno, and it is worth asking why this is so.

The historian Francisco Yates,(2) who investigated the story of Bruno's life, proposes that Bruno was a follower of ancient hermetic, magical and Kabbalistic traditions. Several historians have guessed that Giordano was greatly influenced by Neoplatonism and that he practised various occult customs. Is this the only reason why this philosopher has not been taken into account?

**Dogma or Heresy**

Filippo Bruno (1548-1600) was born in a place near Naples called Nola. At an early age he entered the Dominican order and adopted the name of his metaphysics professor, Giordano.

Very soon he began to question various ecclesiastical dogmas, which led to him being suspected of heresy; thus he was forced to flee and then travelled constantly from place to place propounding his cosmological concepts. Finally he was imprisoned in Venice in 1592 and died on the scaffold seven years later without ever renouncing to his convictions.

Yates' arguments help explain why Bruno was almost totally eclipsed by Galileo, but we wonder if there was no other issue in the background. To answer this question we have to take up a matter mentioned at the beginning of this article, that of "scientific method".

Another historian who studied Bruno's life, John D. Bernal,(3) proposes that Bruno "was a martyr for freedom of thought rather than for science, as he never made experiments or observations, but he insisted up to the end in his right to draw conclusions which he sustained supporting himself on scientific facts".

Everything would seem to indicate that Galileo, the experimental scientist, has been honored by history, while Bruno, because of his somewhat hermetic ideas, and especially because he did not follow rigorous scientific techniques, has been disdained.

### Magic, Philosophy and Science

Pierre Thuillier (1) exposes a grand paradox about the experiments carried out by Galileo, citing various authors who express doubts about whether this philospher-scientist was really in conditions to carry out integrally all the experiments which he relates.These authors also observed that, given the margin of error which Galileo's experiments might have had, they were not so relevant in the development of his theories: that is, the conception of his ideas was made first, and his experiments were perhaps of a secondary nature.

Maurice Clavelin proposes that Galileo could have considered possible the "rational intuition" of the "essences" that is, he might have held a purely speculative vision of nature's make -up and structure. Yet we have just seen that precisely for this reason, John D. Bernal disqualified Bruno when he described him as "more a martyr for freedom of thought than for science".

This does not mean that Galileo did not carry out experiments; several of his manuscripts give us faith of these, but it does open the possibility of conceiving the idea that we can examine and interpret nature through other channels, not only though that of scientific experiments. Where do magic, philosophy and science begin and end? In some cases of very specific knowledge, it is relatively easy to delineate these three areas, but in other cases the difference is fairly slight.

Giordano Bruno definitely had a more spiritual idea of cosmology, but Galileo did not entirely escape from this. Carlos Maya A. (4) states that Bruno's ideas "are more than a beautiful metaphor. They constitute a conception of nature's abundant vital force". And he adds: "it is difficult to evaluate the ideas of this genial heretic ridding ourselves completely of all (pseudo) scientific prejudice".

We are not trying to judge either Galileo or Bruno–this was already done by the Inquisition, when both philosophers were found guilty; rather, we are pondering the idea of science which we have gradually developed and which today governs us.

Do we really have a science which is totally free of magical concepts, of intuitions and inspirations? Can we draw a really clear line between where our reason and our spirit begin and end?

Probably, had we followed the Brunian line of thinking, our "science" would be other (if we would call it science), although we won't venture to say whether it would be better or worse. But what is a fact, is that in our scientific development where reason rules over every other circumstance, we have sometimes been led into a blind alley, at least up to the present moment- for instance, the disastrous effects of nuclear and biological warfare, the extinction of species, etc. That is, it has left us unable to understand what is our role in nature.

However that may be, Bruno and Galileo had the honor of searching for knowledge and of advancing in this search, and each left us a philosophical and historical legacy in science.

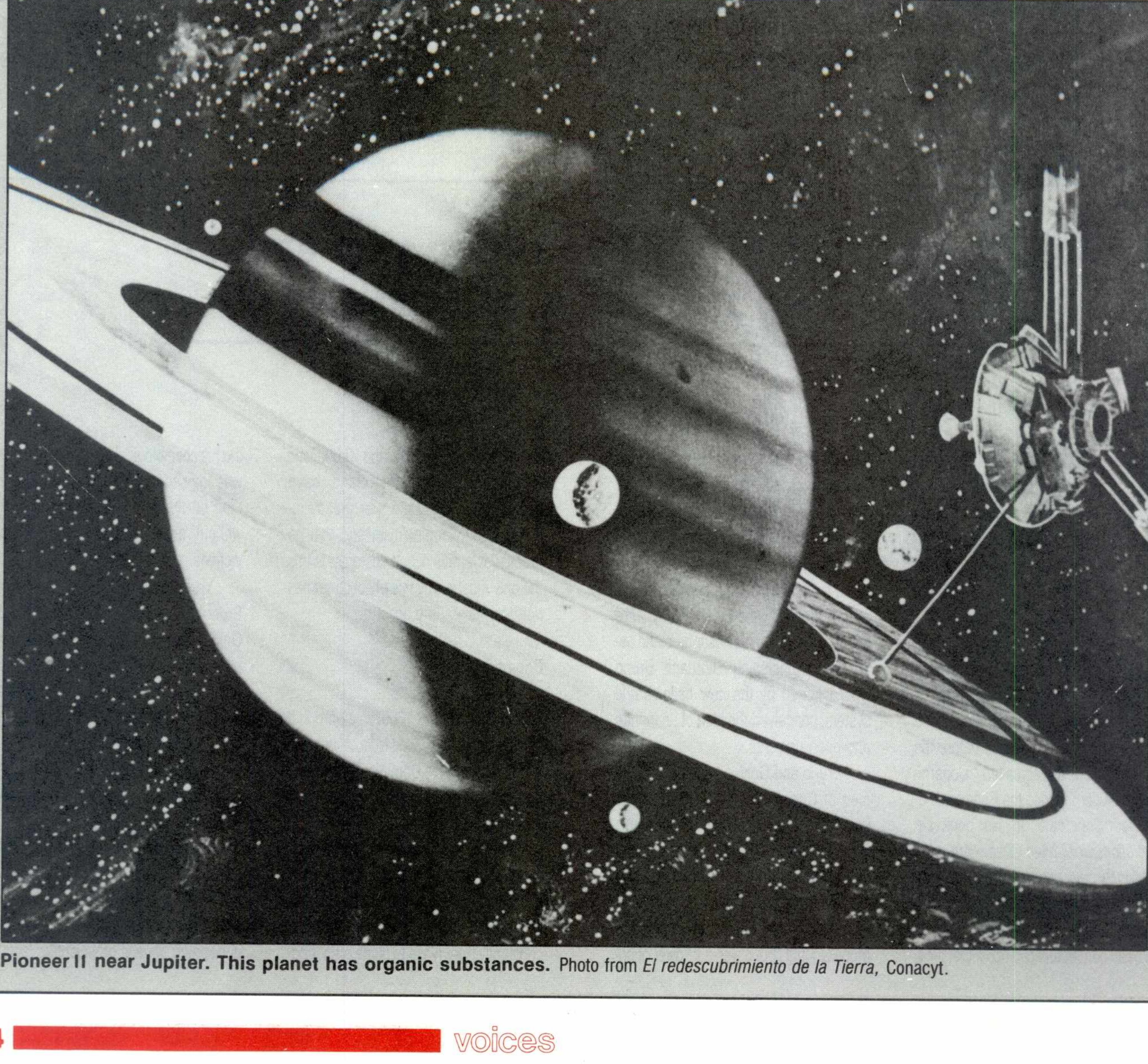
#### Notes


1 Thuillier, P. "Galileo y la Experimentación", En: *Mundo Científico.* Vol. 3, No. 26 pp. 584-597.

2 Thullier, P. "Mártir de la Ciencia o Iluminado? El Caso Giordano Bruno". En: *Mundo Científico"* Vol. 8 N. 81: pp. 618-622.

3 Bernal, J.D. 1979 *La Ciencia en la Historia* México: UNAM y Ed. Nueva Imagen, p. 693.

4 Maya, A.C. 1989. "Muerto Galileo. . . ¿Volverá Bruno? En: *ICYT,* Vol. 11, N. 149 pp. 10-12.

**Pioneer II near Jupiter. This planet has organic substances.** Photo from *El redescubrimiento de la Tierra,* Conacyt.

### The Outer Planets

Beyond the orbit of Mars there are many other bodies in the Solar System of interest in our efforts to understand the processes of the origin of life on Earth, and of possible exobiological implications; nevertheless, temperatures in this part of the planetary system are apparently too low to permit the appearance and development of live organisms.

In spite of the low temperatures, some bodies, such as Jupiter and Titan (one of Saturn's moons), can be places where processes of chemical evolution, similar to those that preceded the origin of life on Earth, are occurring. Jupiter is the most massive planet of the Solar System, and although superficial analysis would eliminate it as a place of interest from the exobiological point of view, due to its high gravity level and its low temperatures, its atmosphere is composed of methane, ammoniac, hydrogen and water, which make it comparable to the secondary atmosphere once possessed by the Earth.

The atmospheres of the outer planets, in particular that of Jupiter, are probably composed of gases that formed part of the solar nebula. In spite of the fact that the outer atmospheric layers of Jupiter are certainly made up of a great quantity of ammoniac ices and ices of other compounds, a greenhouse efect also exists which raises the temperatures of the outer layers.

### Exotic Biochemistries?

In spite of the extraordinary diversity that is observable in the living world, there is a fundamental biochemical unity among all terrestrial organisms, which depend, among other factors, on the chemical properties of carbon and the utilization of water as a solvent. Nevertheless, some authors have suggested that in other parts of the Universe, forms of life with totally different chemistries to those of terrestrial life could exist, which would permit them to survive environmental conditions in which life as we know it, would not even be able to originate; a possibility that sometimes is mentioned, for example, is that of the organisms that would use ammoniac as a solvent, which has a freezing point lower than that of water and that thus would be able to remain in a liquid state on planets where water would be solid; or else, in contrast, forms of life based on silicon or sulphur, which could resist temperatures much higher than those that terrestrial organisms could survive without burning up.

As interesting as these possibilities might be, it is not very probable that organisms with biochemistries based on different elements other than carbon exist.

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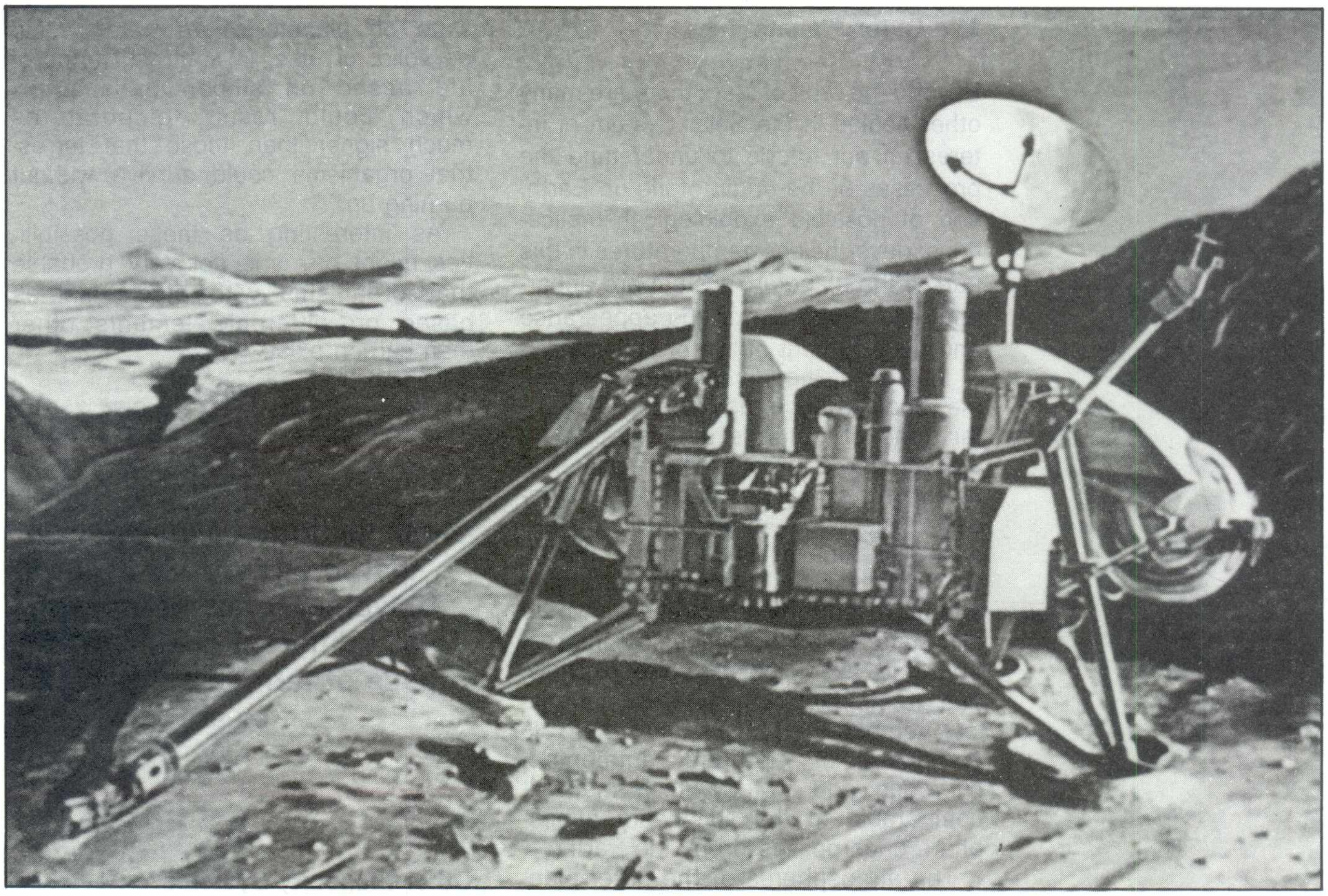
### Other Planetary Systems?

Although for much time it was believed that the formation of the Solar System had been the result of some relatively uncommon event in the galaxy, such as the collision of two stars, in contrast, today astronomers are inclined to believe that the origin of planetary systems such as our own may be a common process in the evolution of dense clouds of interstellar material.

How many planetary systems exist in the Milky Way? This is in reality a difficult question to answer; unlike stars, which emit light, planets only reflect light that they receive from the Sun. This translates into almost insurmountable difficulties in the direct observation of planets associated with other stars, although we may indirectly detect them from gravitational disturbances in the movement of the stars around which they revolve. Several stars exist in the vicinity of the Sun which seem to have associated dark companions with masses comparable to those of Jupiter and Saturn, and other bodies with dimensions comparable to those of our planet perhaps might exist.

A large number of stars in the galaxy are found forming socalled multiple systems, where if planets exis-



**Viking mission. Searching for life on Mars.** Photo from *El redescubrimiento de la Tierra,* Conacyt.

ted, it would be difficult for biological systems to develop. A planet associated with a multiple system would surely have very complex orbits which would distance it too much or bring it too close to the stars, which would result in great variation in temperature, which would in turn prevent the appearance and development of life.

Very massive stars apparently do not have associated planets, the presence of which it is possible to deduce indirectly through the speed with which the stars revolve. In the case of the Sun, this revolves slowly, while the planets possess the greater part of the total angular movement of the Solar system; on the other hand, the periods of evolution of very massive stars are relatively short, given that they quickly transform their hydrogen into ice, which prevents the emergence of living beings when the star undergoes a series of violent changes during its evolution. Stars of lesser mass, in contrast, emit such little energy that the planets associated with them would with difficulty have the radiation necessary for the appearance and development of life.

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In spite of all of these restrictions, only in our galaxy there are approximately 2.5 × $10^{11}$ stars with characteristics similar to those of the Sun, around which could exist planets where life could have originated.

Such a high number of stars of solar type has brought many a scientist to ask on how many planets of the galaxy could life have emerged and evolved until the appearance of societies whose degree of development were comparable or even greater to that achieved by human societies on Earth.

Do other forms of intelligent life exist in the Universe? Today there are many scientists who respond affirmatively to this question, and who believe that it is valid to attempt to communicate with them. Certainly the distances that separate stars from one another seem to nullify all possibility of direct contact; but it would be possible, in principle, to detect interstellar messages sent by radio bands that terrestrial radiotelescopes could receive. The few attempts carried out up to now have had negative results, which is not surprising.

How to communicate with other forms of intelligent life that exist in our galaxy? Where do we begin to listen? How to recognize and interpret an interstellar message that we may eventually capture? In reality, these are questions for which many answers may exist. Messages that have already been sent from Earth toward outer space using radiotelescopes were designed under the assumption that any extraterrestrial civilization with a degree of technological development would allow them to capture and interpret them correctly. □