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Lecture by Mrs. Mary Warren Schiffmann,
Amateur Astronomers Association

"Life on Other Planets?"

Mrs. Schiffmann began by stating a definition of "life." It must fulfill two conditions. First, it must be chemically complex (on earth the main ingredients of this complexity are carbon, oxygen, hydrogen, and nitrogen, with other elements in trace amounts). Second, life must derive its energy from chemical processes; on earth we see three such processes at work: fermentation (one-celled organisms); photosynthesis (plant life); and combustion (complex animals). For intelligent beings capable of space travel, it seems as if we must have a creature that uses combustion - that is, the combination of oxygen with other elements.

Mrs. Schiffmann then presented current scientific views about the origin of the solar system and of life on earth, based on ideas and theories worked out during the past 15 years. In 1941 Lyman Spitzer proved that all previous theories of the origin of the planets from the sun were unsound; and about the same time a new theory was worked out by von Weizsaecher and Kuiper. This theory made use of the studies in turbulence which have been applied successfully to gases, to smoke, to oil in the Big Inch, and to interstellar matter. No serious objection to the theory has been raised in 15 years. It postulates that the solar system began as a huge globule of gas, cold and dark, perhaps one light year in diameter, probably caused by the turbulence of interstellar material. Today's astronomers can see similar objects elsewhere in the universe - huge dark masses silhouetted against bright nebulae; that is, the same process that formed our solar system appears to be going on elsewhere in the universe.

Under the operation of its own gravity, this huge mass contracted and became hot; at its center, hot enough to form the sun. But not all of it went into the sun; at various distances from the center, smaller eddies formed, condensed, and became hot; these masses of matter were the raw material for the planets and their moons. The eddy that became the earth formed at a distance from the sun where the temperature is that of the melting point of ice - an important factor in the possibility of life's originating on earth.

The moon, however, seems to have gotten "stuck" at some point in this process; there is still some volcanic activity on the moon, apparently, but on the whole it seems to be in the same state today that the earth was about two billion years ago. The earth was large enough to hold an atmosphere. Meteors striking the earth went into the atmosphere rather than into the ground. Furthermore, the atmosphere meant that the process of erosion by rain and wind could go on (and at a time when there was no vegetation to delay this erosion). Therefore there are very few "fossil" meteor craters known on earth; two have been found, one in South Africa and one in Germany.

On the moon, by contrast, the atmospheric molecules escaped because of the weaker gravitational pull. Larger meteors headed for the moon would hardly be slowed down at all by the thin atmosphere; they would crash quickly on the surface, and their energy would be dissipated as heat. If the moon were just about at its melting point, each meteor would melt about as much lava as its own mass.

The resulting "lava lake" would cool quickly on top, very slowly underneath; long before it cooled, another meteor would crash, making another crater. This happened so often that parts of the moon now look like an oversized thimble. The last big meteor (diameter estimated at about 100 kilometers) crashed in Mare Imbrium, creating a tremendous flow; almost everything we see as the "face of the Man in the Moon" is the result of this meteor. One of the last craters formed was Plato; and the changes in this crater are probably not finished yet.

There is an interesting confirmation of this combination meteor-volcanic theory of the origin of the craters on the moon. Since ballistics uses the same mathematics as astronomy, during the war many astronomers found themselves working on ballistics. One of these was Dr. Baldwin, who was studying bomb craters. For security reasons, he could not publish all his results, but he worked out a relationship between the diameter of a crater and its height. He plotted this on a logarithmic scale, and got a straight-line correlation between the two figures for bomb craters. Applying this to meteor craters on the earth was difficult, because the exact depth is known for only four of them; but these four craters showed exactly the same relationship as the bomb craters; and the craters on the moon - for all of which it is possible to measure the depth quite accurately - also fell along the same straight line.

Meanwhile, the atmosphere of the earth about this period was composed of hydrogen, perhaps some helium, methane, ammonia, and water; probably no free oxygen, perhaps a small amount of carbon dioxide. The important thing is that these materials, in combinations, will of themselves form amino acids. It has been done in the laboratory; Dr. Urey had one of his students assemble these substances in a closed circuit, and sent an electric discharge through it. A week later, tests showed that amino acids had been formed. Earth was itself a huge laboratory, with billions of years to carry out the experiment. The electric discharge was provided by thunderstorms and by ultra-violet rays from the sun - little or no ozone was in the atmosphere at that time to stop such rays.

These amino acids dissolved in the ocean, which can be described, in those years, as a "thick organic soup." The proteins formed from the amino acids then came together to form life; from then on evolution could take over. Organisms lived by fermentation; photosynthesis began to liberate oxygen from carbon dioxide; finally there was free oxygen in the air, and the earth could begin to have the kind of life that we know most about.

How long did this take? The age of the entire universe seems to be about 10 billion years, and since the oldest rocks on earth seem to be about 2 billion years old, the earth itself is presumably somewhere between three and 10 billion years. The beginning of the Cambrian epoch was a mere 500 million years ago; this is when fossils began to appear - shells, which have been able to withstand the rock pressures, because they are made of carbonates; but you cannot form carbonates until there is carbon dioxide in the air.

How many other stars could have planets with intelligent life? It used to be thought that planets are a very rare occurrence - perhaps 1000 in our galaxy, not more. We now believe that they can be much commoner than this. We can make a rough estimate of the numbers, as shown in the following table:

Estimated number of stars in our galaxy	1,000,000,000
If half of these have at least one planet, there are	500,000,000 planets
If 2 percent of these planets have a temperature suitable for "life," there are	10,000,000 planets with "life"
If 1 percent of these ten million planets have "intelligent" life, there are	100,000 planets with "intelligent" life

This figure is correct to a factor of 100,000 either way - after all, we know there is one planet with "intelligent life."

Scatter these 100,000 planets around our galaxy, and not many of them will be near the earth. The nearest star to us is invisible (14th magnitude) to the naked eye; Alpha Centauri, which is both "near" (4.3 light years) and visible, is a double star, and any planet of a double star would be so hot at times that it seems unlikely that life could start there. Alpha Centauri does have a third component, but this is a very cold star.

No other planets have actually been observed elsewhere in the universe; several are strongly suspected to exist because of irregularity in the orbits of their "suns," but it takes a long time of observation of these stars to prove that their motion is irregular, indicating the existence of planets.

But aside from the moon, what about the other bodies in our own solar system as suitable for life? On the outside of the sun the coolest spots are 4,000 degrees Centigrade. The inside is much hotter; atomic energy, which the sun is known to produce, is not produced at any temperature under 6 million degrees. Mercury, the planet nearest the sun, keeps the same face always toward the sun, and the temperature of the center of that side is about 650 degrees. On the other side it is as cold as interstellar space. There is no indication of an atmosphere. In the zone between hot and cold it might just be possible to land a rocket ship.

As for meteors and comets, their orbits are too eccentric to encourage life - sometimes near the sun, sometimes far from it. All the small satellites of the planets are too small, and so are the asteroids; the largest of these is 200 to 400 miles in diameter. If a body is too small to hold an atmosphere, no liquid substances are possible. Liquids "boil away" on such bodies at a very low temperature. (Water boils at 67 degrees Fahrenheit on Mars.) The moon, as stated, has no atmosphere, and probably no water unless in underground caverns. There is some volcanic activity there, but if there is "life" it is hardly anything more elaborate than a one-celled organism.

Of the large moons of the planets, Titan (Saturn) has a methane atmosphere, probably frozen. Two of Jupiter's four large moons probably have ice, but no atmosphere; the other two are also too cold. On the five outer planets, we can measure only the outside temperatures of their atmospheres; we do not know what the "greenhouse effect" is with methane or ammonia. On Jupiter the worst difficulty is its huge mass; the pressure would make slush of everything, we would drown in frozen methane. There is a lot of water, frozen, and there is a core of solid rock, but we do not know how far down in the atmosphere it is. On Saturn, Uranus, and Neptune the same story, but they are even colder than Jupiter. Saturn probably has a lot of water, because its density is less than that of any other known body in the solar system, and the famous rings are probably particles of ice. Pluto, the most distant planet, is colder than all the rest, and seems to have no atmosphere.

This eliminates everything in the solar system except Venus and Mars. Venus is one big question-mark. Its curtain of clouds never thins or disappears; we do not even know its period of rotation. The clouds show nothing but carbon dioxide (CO_2). Dr. Urey said that if there was ever any water on Venus, by now it has all combined with the CO_2 to form carbonates; that is, the water is all locked up in rocks, and Venus is a desert under all that cloud. This has not happened on earth because we have a state of equilibrium; the CO_2 is used by the vegetation. On Venus there is too much CO_2 for equilibrium; therefore, no water. But Dr. Whipple and Dr. Menzel have recently come forward with an alternate theory: Venus may be all water. If so, then Venus is pelagic; all life is in the oceans, with probably very little photosynthesis; for photosynthesis produces oxygen, and we cannot detect any oxygen in the atmosphere of Venus.

There is no curtain around Mars; the atmosphere is very clear, also very thin. Slice off our atmosphere at 10,000 feet, take out all the oxygen from the upper slice, and that part will be much like the air on Mars. Mars has some water; the polar caps are frozen water, probably not very thick. There are no ponds, pools, or oceans, but there is water vapor, because the polar caps melt in the Martian spring; and a "wave of quickening" then moves from the pole to the equator as the icecap recedes, and the color of the planet becomes green or chocolate brown. Does the green denote vegetation? From outside the earth, the Sahara would appear brighter than Canada, because the vegetation in Canada absorbs solar heat (for photosynthesis), while desert sand reflects it. If Mars has vegetation we ought to be able to detect chlorophyll - which we do not see; and we ought to observe a higher temperature on the red parts of the planet, which are presumably the parts without vegetation. Instead, we find that the green parts of Mars are actually hotter than the red parts.

Every book will give you a different answer about Mars. But even if there is life there, it is almost certainly a dying planet. Intelligent and ingenious beings might be able to provide themselves with air by some means, but how would they provide food?

The only report so far on the 1954 observations of Mars is a second-hand one about a measurement of temperatures made in Russia. In 1956 Mars will be closer to us than it has been since 1924, and astronomers will continue their intensive study of these problems. They hope to be able to take movies - which will help get around the problem of our own shimmering air - and to use the electron telescope.

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In the question-and-answer period that followed her main talk, Mrs. Schiffmann answered a number of questions about Mars. Referring to the "canals," she said that it is still debated whether these are real, objective markings. They do appear on some photographs; but the interpretation of the markings is in doubt; it is possible that film, like the human eye, blends separate spots or marks into seemingly straight lines. However, the "wave of quickening" certainly does follow the "canals." She stated that there is some evidence (cont. page 5)

of a former oxygen age on Mars, since the red parts of the planet may be oxides. The suggestion was made that since desert plants and animals on earth have adapted themselves to life without water, life on Mars might have accomplished the same thing. Mrs. Schiffmann said this was possible, especially since any Martain race would probably be more intelligent than we are. She also suggested that CSI members read Sky and Telescope for February, 1955, which contains (in addition to the article mentioned below) an article about gray clouds and bright flashes ("explosions"?) on Mars.

A member of the audience asked whether astronomers would concede that an intelligent race 10 million years old might have succeeded in traveling faster than light. Mrs. Schiffmann pointed out that this part of Einstein's theory - that nothing can go faster than light - has never been questioned by scientists. A fundamental difficulty is that any body traveling at the speed of light acquires infinite mass. Nothing we know of does travel as fast as light, but certain fast electrons go at one-tenth the speed of light, and as Einstein predicted, their mass becomes much greater.

In answer to a question about the possible existence of another moon behind the known one, Mrs. Schiffmann said that if so, the extra moon could not be very large, as it has not had any noticeable gravitational effect on the moon. Another question was, "The moon is said to be approaching the earth; will it eventually explode and form a ring of particles like Saturn's?" Mrs. Schiffmann said that the calculations about this are very delicate, and that it is now believed that the moon is in fact receding from the earth.

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The bibliography supplied by Mrs. Schiffmann in connection with her talk, for those who wish to read more about these questions, follows:

For basic information:

Sir Harold Spencer-Jones, Life on Other Worlds (MacMillan, 1940)
Fred L. Whipple, Earth, Moon and Planets (Harvard University Press, 1941)

On special cases:

Hubertus Strughold, The Green and Red Planet (Univ. of New Mexico Press, 1953)
Gerard de Vaucouleurs, The Planet Mars (MacMillan, 1951)
H. Percy Wilkins, Our Moon (Frederick Muller, Ltd., 1954; Macmillan, 1955)
(Note to CSI members: This is NOT the same Wilkins who wrote Flying Saucers on the Attack.)

Prejudiced in favor of life:

V. A. Firsoff, Our Neighbor Worlds (Hutchinson, 1952)
Kenneth Heuer, Men of Other Worlds (Pellegrini & Cudahy, 1951)

Difficult but rewarding:

Harold C. Urey, The Planets: Their Origin and Development (Yale Univ. Press, 1952)

Recent magazine articles;

George Wald, "The Origin of Life," in Scientific American, August 1954
Otto Struve, "Life on Other Worlds," in Sky and Telescope, February 1955
Bruce Bliven, "Is There Life on Other Planets?" in Readers Digest, February 1955