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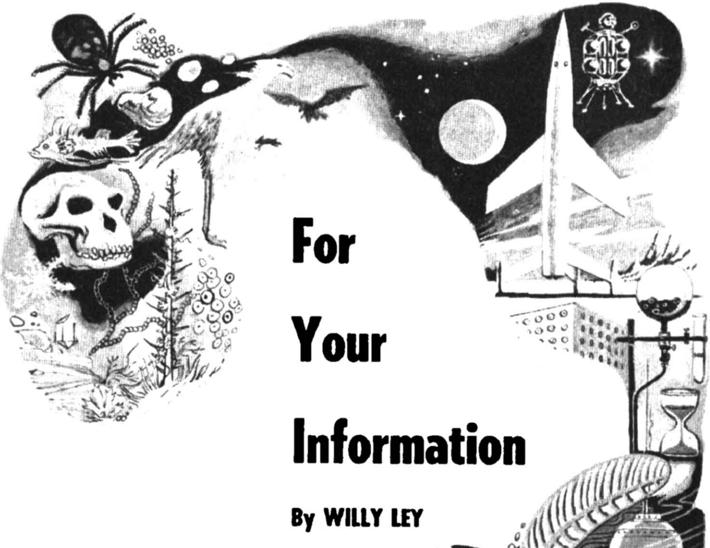
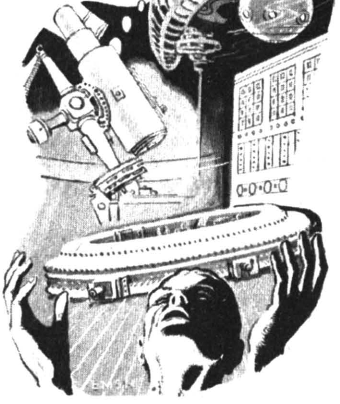


For Your Information

By WILLY LEY



IS ARTIFICIAL LIFE POSSIBLE?

EARLY this year, a young scientist, Stanley L. Miller of the University of Chicago, made an important discovery. Like many other scientific discoveries, it was exciting to the specialist who is aware of all the background, but needs a considerable amount of explanation for a layman to realize its significance.

What happened was that Mr. Miller tried to duplicate under glass the conditions which probably prevailed on Earth some two thousand million years ago. At that time, cosmological theory says, Earth's atmosphere must have been entirely different from what it is now. It was an atmosphere which every living thing of today, with the exception of certain bacteria, would find poisonous.

When the job of imitating the surface of the Earth before life began was done, it was found that some chemicals had formed in the process. Not surprising in itself, except that the chemicals were *amino acids,* which are the building blocks of *protein*—and that is the basis of life.

LET'S sit back for a moment and draw a kind of bookkeeping balance. To begin with, we have the undeniable fact that life does exist on Earth. Even half a century ago, it was known that, at some time in the past, life could not possibly have existed on Earth, for you can't have anything living on what amounted to a ball of lava. Therefore life on Earth must have started at some relatively specific time. After you had progressed so far in your reasoning, you had the simple theoretical choice of postulating that it originated on Earth in some manner from things we'd call "non-living," or that interplanetary and interstellar space is full of life spores which continuously fall on every planet and either perish or settle and multiply, if conditions permit them to do so.

At a later date—over three decades intervening—physicists began to work out how the Earth's surface must have looked after it had cooled, deriving a picture decidedly inimical to life, even though the excessive heat was gone. There would be no oxygen in the primeval atmosphere; that had all been oxidized away. There would be ammonia, carbon dioxide, carbon monoxide, methane gas and water, the latter in both forms, vapor and liquid. There would be, in addition to these material things, energy, sunlight with radiations of all wavelengths, from long radio waves down to X-rays, and probably electrical discharges.

When that environment was produced in the laboratory, it yielded amino acids!

Don't jump to conclusions at this point. Amino acids are as far removed from a complete, large and complex protein molecule as a pile of bricks is from a finished house. And a finished protein molecule is a long—though unknown—distance from a living cell. The experimenters did not (as things are easily exaggerated) make a living cell in Chicago, but merely substances which we now know to be sub-sub-assemblies of a cell.

Nor can one extrapolate from here on and say hopefully: Now that they have succeeded in creating the sub-sub-assembly from dead substances, next week (or month, or year) they'll get a few thousand amino acid molecules together and make a protein molecule. And the week (or month, or year) after that, they'll get a living cell. Even so—

But to make my thinking clear, let's assume that somebody, in the course of reproducing primevil. Earth environment, does obtain a living cell. There would then be just two possibilities:

1. It did happen in the way in which those amino acids happened. In that case, virtually the whole of the secret of life would still need to be investigated, because all we would know is that it happened (admittedly a good deal) and we would still have to find out how and why.

2. The researcher knew all the factors involved before hand, in which case the experiment would only have been the proof of a well-formulated and presumably complicated theory of life.

WE don't have such a theory of life. In spite of a really enormous amount of work performed during the last seventy or eighty years, we have trouble even *defining* life. At first a purely chemical definition was tried, until it was realized that analyzing protoplasm was like melting down and analyzing a locomotive to see why it works. Then followed a long period in which not the chemical nature, but the chemical (and physical) actions were taken to be the main criterion.

A favorite example was an ordinary egg—or, rather, two of them, one fertilized and the other not. They were obviously alike chemically, yet one developed into a chick and the other would rot after a while. And if somebody objected and said that fertilization therefore must have introduced a chemical change, you could point out some rather incredible things researchers had done with eggs, if not chicken eggs.

For the eggs of a sea urchin could be "fertilized" by brushing them with a medium-hard brush under water, or by sticking a needle into them—gently, of course. It worked with butterfly eggs, too. Now all this could do was to push some substance from the outer layers into the interior. The result was fertilization, decidedly without introducing a chemical change of the whole.

Well, all right, in which way

did a living thing act differently from a dead substance? First of all, it would eat and grow, by taking in substance from outside its body. Crystals also grow, but they have to be in a solution of the same chemical substance, while a living cell could digest and "assimilate" different substances. At the time, some philosophers objected that this was true not only of living beings. A candle flame "assimilated" the wax. That flames could grow and multiply and that they would leave behind the "indigestible" things which could not be assimilated, or only partly assimilated, did not need any special and elaborate proof. At a later date, chemists came up with the so-called autocatalytic compounds, substances which can also be said to "assimilate" other compounds.

So the definition by "action," even if well meant, could not be phrased sharply enough to be fully acceptable. A much more recent definition also works with "action" and has been condensed as follows:

A slab of beef is protein. A live animal is, too. Put them both on a board and tilt it. The steak will follow the laws of gravity; the live animal will fight back. Of course it may not succeed, but it will try.

You will have noticed that this discussion has wandered far afield, from what amounted to attempts to find a chemical formula for life, to the "intent" of fighting gravity. But this is merely an indication of the fact that we are dealing with a very complex problem which can be approached from many angles and somehow eludes a fine sharp definition.

IN the foregoing, a number of parallels have been mentioned. A crystal will grow like a living cell, but only if it has the chemicals which constitute it to feed on. An autocatalyst can go a step further. And a flame—a purely chemical process and a very simple one at that—not only seems to assimilate, but also to propagate.

Granted that the example of the flame is a superficial similarity, don't the other two indicate that there is no hard and fast borderline between living and non-living things? And didn't Dr. Wendell M. Stanley of the Rockefeller Institute for Medical Research in Princeton jump across this line one and a half decades ago when he succeeded in crystallizing a virus (the virus which produces the so-called mosaic disease of the tobacco plant) without killing it?

For those who did not read about it at that time, I'll briefly explain that the crystals, to all intents and purposes, appeared to be as "dead" as beach sand or ground glass. Yet when they were put on the leaf of a tobacco plant, they caused the mosaic disease as if they had been subjected to no change of form.

Naturally the conclusion was drawn that not only the tobacco mosaic virus, but any virus belonged in that border area between living and dead matter. Since then, we have learned one very important fact about viruses. Besides differing from bacteria in being much smaller, they are also much more specialized in their demands. A bacterium can force its way into the cells of a bigger host and live there, or it can live outside a cell. A virus needs the environment of a living cell; in that, it is reminiscent of the crystals which can grow only in a very specific environment.

Now the question is: Is a virus actually such a borderline case which has not progressed all the way to the adaptability of truly living matter? Or is a virus a degenerated parasite which—like far larger and far more complex parasites high up in the ladder of evolution—has lost most of the adaptability it once possessed for the sake of the apparently easy life of a parasite?

Personally, I feel inclined to suspect the latter. But either explanation may be correct. I don't think anybody really knows yet.

That, unfortunately, is the note on which this little dissertation has to end. When it comes to questions like the suspected border area between living and non-living matter, our knowledge is simply insufficient to pass judgment.

And the Chicago experiment?

It has done two things. It has strengthened the supposition that life could originate on Earth after the planet cooled. It has opened up a new avenue of research which looks promising.

In time, the dramatic experiment might lead us to an understanding of what life really is. And after we have succeeded in understanding, the creation of artificial life would probably be a process of extension—protein molecule, cell, linked cells, and so forth, perhaps all the way up to synthetic human beings, the "androids" of science fiction. But the creating of amino acids is only the beginning of that long climb, analogous to Franklin's kite to attract lightning and the awesome complexity of modern electrical generation, power transmission and consumption.

The experiment shows us that it apparently can be done. If artificial life is created, however, it would just be the confirmation of a theory that had been worked out beforehand.

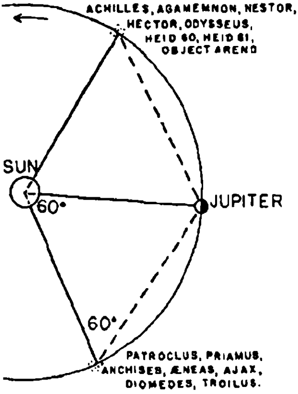
As you can see, we need the theory first. Only after we have that can anybody state whether artificial life is a definite likelihood. Until then, it remains a theoretical possibility, though a good one, I believe.

THE TROJAN PLANETS

As a result of a recent story involving the Trojan planets, several readers inquire what they are and whether they exist, and another wants to know if there is a minor planet named Agamemnon and where it is located.

The story of the Trojan planets began either in 1908 or in 1772, depending on your point of view. On February 22, 1908, Prof. Max Wolf discovered a minor planet in a place in the sky where none of the known minor planets (or planetoids) could be that night. Of course it might also be a new comet, so it was provisionally and noncommittally labeled *TG*. Observations of *TG* over a period of time made it likely that it was not a comet and the observations were mailed to Dr. Berberich in Berlin, head of the special computing section for minor planets. It turned out to be planetoid No. 588 and Dr. Berberich announced that it appeared to move in the orbit of mighty Jupiter.

The brightness of No. 588 seemed to indicate that it was fairly large for a planetoid, with an estimated diameter of 150 miles. The discoverer then named it Achilles and the next problem was to find out whether it was actually in the orbit of Jupiter. It was Prof. Charlier of Lund



Observatory who was the first to notice that the position of Achilles was some 55½ degrees ahead of Jupiter in its orbit.

That such a thing was possible at all had been predicted quite some time earlier, when Joseph Louis Lagrange had published an essay on "Three Bodies" in space and how they would move under the mutual gravitational attraction. That had been in 1772 and Lagrange had found mathematically that three bodies could form a stable system if they were arranged in the three corners of an equilateral triangle. The triangle, in this case, consisted of the Sun, Jupiter and Achilles.

During the same year, planetoid No. 617 was found and named Patroclus. It also formed an equilateral triangle with the Sun and with Jupiter, but in the other direction, since Patroclus trailed Jupiter in its orbit. And then it turned out that another new discovery, No. 624 (named Hector), was close to Achilles. Further observation showed that Achilles and Patroclus were members of small clusters of planetoids, one group moving ahead of Jupiter and one behind it. They were all named after heroes of the Trojan War, hence the general appellation of Trojan planets.

The trailing group comprises seven known planetoids. The leading group has five well-established members, to which the Germans have tentatively added three that, for the moment, do not yet bear classical names.

Since they are moving in this formation, the same set of figures applies to every one of them. They all move with an orbital velocity of 8.1 miles per second, need 11.86 years to go around the Sun once, and their average distance is 483 *million* miles. That is the distance of each group from the Sun and of each group from Jupiter and, of course, the distance of Jupiter from the Sun.

Because this is also a considerable distance from us, it is obvious that each group must have many more members than have been named, for at that distance we can find only comparatively large bodies. It is very likely that small ones, say a mile in diameter, move around in these clusters. A good deal of space débris is likely to be present, too.

The motions inside these clusters must be very interesting, but we know comparatively little about them. We don't actually have to go there to find out. This is one of the astronomical problems that could be solved by photographic observation from a space station.

At any event, the Trojan planets are as intriguing—though lacking the popular appeal—as the canals of Mars.

ANY QUESTIONS?

What are the oldest known fossils and how old are they?

Rita Eleftheriades
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New York City.

First let's get the chronology straight so that lack of explanation does not lead to misunderstandings.

Prior to our own era, we had the Cenozoic Era, also called the Tertiary Period or the Age of Mammals, with a total duration of about 60 million years. Before that came the Mesozoic Era, also called the Age of Reptiles, with a total duration of about 135 million years, and, prior to that, the Paleozic Era with a total duration of 355 million years. Before that—still going backward — there was the Proterozoic Era and, before that, the Archeozoic Era, each estimated to have been 650 million years in duration.

For quite a number of years (but also quite a number of years ago), students were taught that a fossil from the Archeozoic was known—hemispherical masses, from a few inches to a few feet in diameter. The name given was *Eozoon canadense*, but although this means "the dawn animal from Canada," it was stated that they had probably been colonies of algae. But it is now believed that *Eozoon* is not a fossil at all. From the Proterozoic Era, a few doubtful fossils are known, one from Australia *(Protaledadia)* and one from the Grand Canyon *(Beltina danae)*, both believed to be early arthropods.

"Arthropods," in case anybody stumbles over the word, is the summary designation of crustaceans, insects, spiders, scorpions, centipedes and millipedes. Spicules of sponges from the Proterozoic of Grand Canyon are less doubtful than the supposed early arthropods, and the trails of an otherwise unknown wormlike animal from the Proterozoic of Glacier National Park are accepted.

The reason for the extreme scarcity of fossils from the first two Eras is twofold: One is the extreme age of these periods and the other is that most very primitive animals and plants do not have solid shells, bones or other structures which can fossilize.

With the first period (the Cambrian Period) of the Paleozoic Era, fossils become frequent.

I have had some difficulty understanding what nebulae actually are. Are they composed of stars, cosmic dust or what? In connection with nebulae, I have heard the terms "planetary," "diffuse," "dark," "galactic" and "spiral." What do these terms mean?

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Yes, the terminology is somewhat confusing.

In Latin, the word *nebula* means "vapor" or "smoke" and *nebulosus* means "clouded." This word was chosen because the appearance of some nebulae suggests vapor or clouds. All nebulae are grouped as either "galactic" or "extragalactic," the former belong to our own galaxy while the extragalactic nebulae are other galaxies.

The galactic nebulae are of three types: dark, diffuse and planetary.

Dark nebulae bear that name because they show up dark against a background of stars, many of which they obscure.

Diffuse nebulae are of irregular outline and shape and are probably visible only because of the light of nearby stars which they reflect.

These two types, which might be essentially the same under different illumination, consist of gas molecules and dust particles.

The planetary nebulae have the most misleading name. They were originally called that because in the telescope they show a disk like a planet, while the stars show as points. They are the gaseous envelopes of certain stars, round or nearly round in shape and sharply defined.

The extragalactic nebulae are subdivided into two types, elliptical and spiral. The spirals are then subdivided once more into "normal spirals" and "barred spirals" and in each of the two spiral types, astronomers distinguish "early," "intermediate" and "late" forms. Since the elliptical extragalactics as well as the spirals are galaxies like our own, generally speaking, their light is due to the stars which compose them.

To round off the survey, I have to add that a number of "irregular" extragalactic nebulae are known and that there are many Q-type extragalactic nebulae. Q-type means too faint to be classified properly.

—WILLY LEY