Protein evolution: Up the down staircase

Experiments indicate that proteins might have evolved on the early earth without the intervention of amino acids

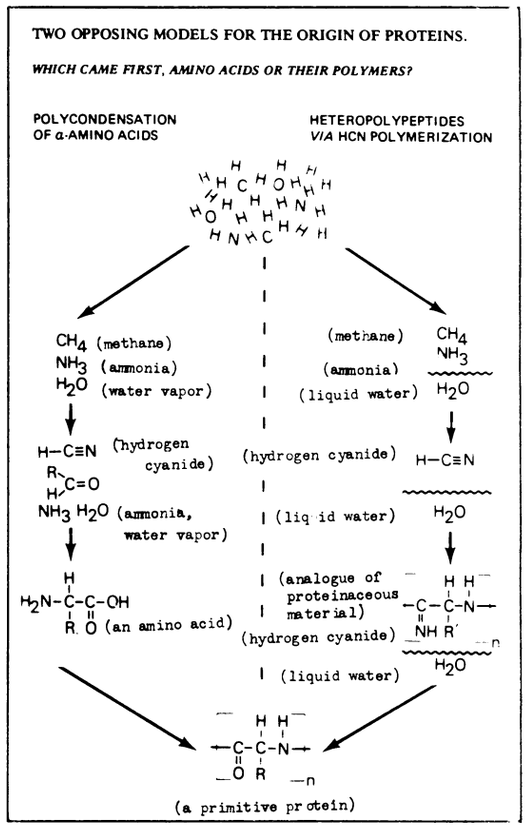
An era in the chemical exploration of biological evolution opened in 1953. Stanley L. Miller and Harold C. Urey of the University of Chicago made four amino acids from a simulated early earth environment that consisted of methane, ammonia, water vapor and electrical discharges. Since then, virtually all of the amino acids that make up present-day proteins have been made under similar conditions. And when Sidney W. Fox of the University of Miami heated these primitive amino acids in the absence of water, they linked together into primitive proteins.

Evidence is substantial, then, that amino acids were first created on the primitive earth, and that these amino acids then evolved into primitive proteins. Such a theory is pleasing to chemists, since it is in keeping with how modern proteins are made.

In recent years, however, Clifford N. Matthews of the University of Illinois has become increasingly convinced that proteins formed on the primitive earth without the intervention of amino acids. He and co-worker Robert Minard presented the latest evidence for his theory at a meeting of the American Chemical Society last week in Chicago. The key ingredient in his experiments is hydrogen cyanide.

Joan Arehart-Treichel

Matthews: Hydrogen cyanide the key.



Traditional model of protein evolution (left side of chart) says amino acids were necessary for protein formation. Matthews' model (right side) says amino acid intervention was not necessary.

Matthews/Univ. of Illinois

It is well known that methane and ammonia, when subjected to ultraviolet light or any high-energy source, give a high yield of hydrogen cyanide. In his earlier experiments, Matthews assumed that the primitive atmosphere was methane and ammonia with water present as liquid rather than as vapor. He put these components together with ultraviolet light and got, as expected, hydrogen cyanide. But he also got a messy brown compound with protein-like properties that further broke down into amino acids. So he thought it possible that hydrogen cyanide on the primitive earth gave rise to proteins in a similar manner. So he, with the help of Minard, set out to chemically document the possibility.

They made a compound analogous to the brown material and treated it with hydrogen cyanide and liquid water. The result was a primitive protein with side chains that are present on modern proteins. So Matthews is further convinced that hydrogen cyanide might have allowed proteins to be made on the early earth without the intervention of amino acids.

If his model of protein evolution eventually proves right, it has two virtues. It bypasses an energetically unfavorable step—the linkage of amino acids into proteins (which in modern protein production is carried out by enzymes, which are themselves proteins). It also shows how the early earth could have been covered with protein-like material that would have catalytically assisted in the formation of nucleic acids, the genetic material of life, in the way that today enzymes assist in modern production of nucleic acids. □

Reverse transcription: Still cancer-implicated

A few years ago, Howard Temin of the University of Wisconsin came up with some valuable scientific evidence. It was that certain RNA tumor viruses could make copies of DNA from the RNA molecules comprising their genetic cores. This feat ran exactly counter to what usually happens in cells, in which DNA, a cell's genetic information, is transcribed into molecules of RNA.

Then in 1970, Temin and David Baltimore of the Massachusetts Institute of Technology made a simultaneous but independent discovery. RNA tumor viruses were able to make DNA from their RNA cores because they possessed a special enzyme. The enzyme was called "RNA-dependent DNA polymerase," or "reverse transcriptase."

The discovery of RNA-directed DNA synthesis and of reverse transcriptase—subsequently confirmed by other researchers—rocked the scientific world. Many investigators hoped that the mechanism and the enzyme would provide a key to the cancer process. Might RNA tumor viruses, with the help of the reverse transcriptase enzyme, convert

their genetic information (RNA) into DNA? Then might the DNA copies of the viral genes be inserted into the DNA of host cells? And might the viral DNA make the cells cancerous?

But research compiled during the past year or two somewhat deflates that hope, or at least makes it harder to document. This fact was brought home last week at a meeting of the American Chemical Society in Chicago.

The reverse transcriptase enzyme, which appeared to be a unique product of RNA tumor viruses, has now been found in noncancer viruses as well. It has also been found in noncancerous cells. It now becomes clear, says Temin, that the enzyme does not always correlate with cancer.

In fact, even RNA tumor viruses may not necessarily lead to cancer. DNA copies of viral RNA are now known to incorporate themselves into the DNA of host cells. But even when this happens, cells do not necessarily become cancerous. "Integration of viral-specific DNA in itself is not the cause of cancer," reports Harold E. Varmus of the University of California at San Francisco.

Have investigators given up hope, then, that RNA-directed DNA synthesis might provide a key to the cancer process? Not really. RNA virus-produced reverse transcriptase does not always turn cells into cancer cells. But transformation of cells by RNA tumor viruses is always accompanied—as far as P. K. Vogt of the University of California at Los Angeles can tell—by viral DNA. The viral DNA has presumably been made by the reverse transcriptase enzyme. So the reverse transcriptase enzyme is necessary, if not sufficient, to cause cancer.

The implication of reverse transcriptase in the cancer process, then, has been amply demonstrated. But what the implication means will only become fully evident when scientists get at the basic genes of viral RNA and identify which genes might transform cells into cancer cells. □

Joan Arehart-Treichel

Temin: It's not a cancer exclusive.

Mesons on the mesa: First from the factory

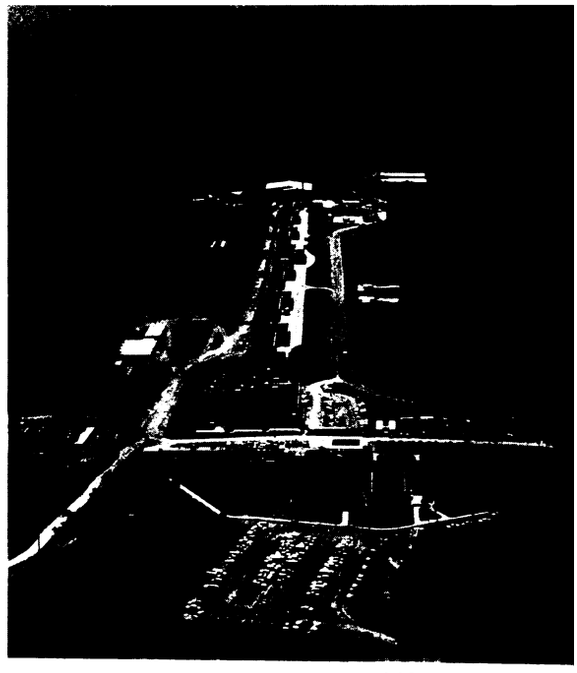
About 10 years ago physicists began to seek the construction of the so-called meson factories. These are machines that would accelerate beams of protons and drive them against targets so as to produce copious beams of mesons, particularly pi mesons. Pi mesons are useful as probes of the atomic nucleus, and nuclear physics stands to benefit greatly from meson factories. So would medicine: Pi mesons have a potential use in the destruction of certain kinds of tumors.

The Clinton B. Anderson Los Alamos Meson Physics Facility (LAMPF) located on top of a mesa at Los Alamos, N.M., is the one project to provide such a meson factory in the United States. Last week it produced its first pi mesons. The event climaxed five years of design, engineering and construction.

The pi mesons were produced in beam area "A," one of three beam areas at the end of the protons' 1,800-foot flight. The area had been declared ready on Aug. 25 and received its first proton beam, of 447 million electron-volts (MeV) energy on Aug. 26. The first pi mesons were produced on Aug. 27. The ultimate plan is to use protons of 800 MeV energy.

Participants in the meson production include Don Cochran, Robert Macek, Robert Burman, Don Hagerman and Mahlon Wilson of Los Alamos Scientific Laboratory and Mark Jakobson of the University of Montana, chairman of the LAMPF Users Group.

The first pi mesons were the signal to begin an effort that includes tuning the main and secondary beam lines and preparing the secondary lines, where the mesons will appear, for experiments. It is expected to take several months. □



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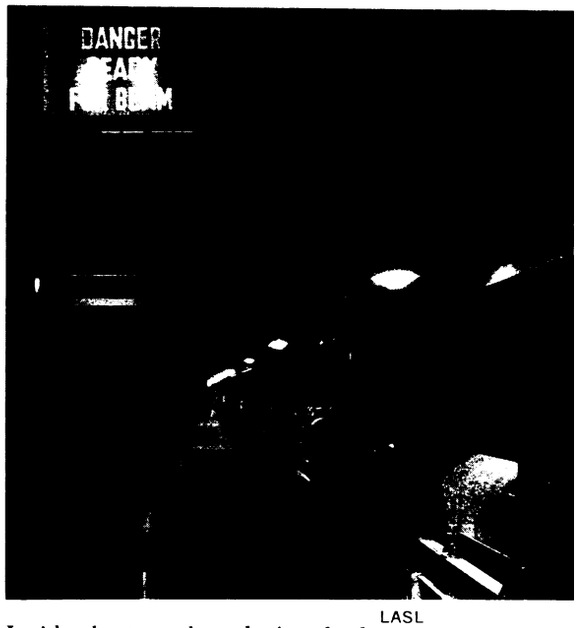
LAMPF, meson factory on the mesa.



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Inside the tunnel ready for the beam.

Are the outer planets 'failed' stars?

The planets of the solar system can be divided broadly into two classes: the terrestrial (Mercury, Venus, Earth and Mars) and the Jovian (Jupiter, Saturn, Uranus and Neptune). (Pluto is left out because too little is known about it.) The terrestrial planets are small, compact bodies with densities greater than about 4 grams per cubic centimeter. The Jovians are large and diffuse with densities less than 2.25 grams per cubic centimeter. The terrestrials all lie within 1.52 astronomical units of the sun. (One astronomical unit is the radius of the earth's orbit.) The Jovians only begin after a sizable gap: Jupiter, the nearest Jovian to the sun, is 5.20 astronomical units away from the sun.

These differences have excited much speculation among astronomers, and the suggestion has been made several times that Jupiter looks more like a small star than a planet. Now comes D. McNally of the University of London Observatory, who argues that all four of the Jovians are "failed" stars. Specifically, he suggests "that the terrestrial planets formed in a high-density shell surrounding the proto-Sun and that the Jovian planets are the remnants of other attempts to form stars contemporaneously with the Sun."

If Jupiter, Saturn, Uranus and Neptune are all indeed failed stars, they failed almost at the point of becoming stars. What inhibited their final collapse into the stellar state? Clearly it was not proximity to the sun: Binary stars are