Modeling early evolution with clay

Lowly clay may have shaped a crucial step in the chemical evolution of life. Metal clays widely spread on the shores of primitive oceans could have selectively bound and linked simple chemical segments into the complex molecules characteristic of biology, propose scientists at NASA's Ames Research Center in Mountain View, Calif.

In laboratory models of chemical evolution, previous experiments have produced small amounts of the basic biological units. But the questions remained of how the dilute amino acids were joined to form proteins and how the nucleotides became organized into genes.

James Lawless, Nissim Levi and their collaborators report that commonplace clays (aluminum silicates), are likely concentrators, selectors and linkers of amino acids and nucleotides. "They [the clays] are like a sandwich," Lawless explains. "The clay lattice is negatively charged and that charge is neutralized by metal ions between the layers." Simple organic molecules can bind to the metal ions in the same way that blood hemoglobin binds to iron.

All clays attract amino acids from solution the researchers found, but there are intriguing differences between clays containing different metals. Nickel clay, for example, seems to attract preferentially the amino acids naturally found in proteins. Among one class of amino acids, the investigators found nickel clay had twice the affinity for the five protein types as for fifteen other amino acids with slightly different arrangements of atoms. The researchers found that another clay destroys amino acids not found in protein. Thus this selectivity of binding and destruction might explain why plants and animals employ predominantly 20 amino acids out of over 1,000 possibilities.

The ebb and flow of tides over millions of years may have linked the amino acid units into long protein chains. When the researchers repeatedly wet, dry and warm a solution of amino acids on clay surfaces, they produce short chains of amino acids. For eight cycles, the maximum length is eight amino acids. Current experiments will run 16 and 24 cycles, but there are no plans to extend the experiment to build a typical modern protein thousands of units long.

So far the experiments have only produced repetitive chains from a single amino acid solution. But the clays, in the linkage process, seem able to distinguish among the amino acids. For example, copper clay links glycines better than alanines, while for zinc clays the ability is reversed. "We think that by using different metals, we can tailor the gross overall sequence of a chain and predict the concentration of each amino acid," Lawless says.

In addition to concentrating and linking amino acids, one type of clay attracts the basic units of genetic material. Zinc clay is the first substance to be found that can successfully absorb nucleotides out of solution, Lawless says. He is particularly pleased with that result because in living organisms zinc, in the enzyme DNA polymerase, is crucial to formation of DNA chains. The importance of metals in living systems today results from prebiological chemistry, Lawless believes.

The investigators have been studying amino acids and nucleotides as if they concentrated separately and simultaneously during chemical evolution. "There are obviously relationships between amino acids and nucleotides," Lawless says. "Future work will have to take this into consideration."

Future work will also consider processes beyond this planet. Metal clays are found associated with organic matter on meteorites, and iron-rich clay is the leading candidate for the predominant material on the surface of Mars (SN: 1/29/77, p. 68). Lawless and colleagues are currently planning experiments in which they will use ultraviolet light to create an environment similar to that of Mars. They are excited about chemistry with clays in hydrous environments on other planets. Lawless says, "It did lots of good things for us." □

The life that came in from the cold

We tend to associate life with warmth. This is particularly true because humans are warm-blooded animals. Life processes generally require temperatures above the freezing point of water, or 273°K. In comparison, the temperatures of the interstellar clouds are only a few, or a few tens of degrees K.

These low temperatures preclude the existence of any known kind of living beings in the interstellar clouds, but more important, they also raise serious problems for scientists who would like to consider the interstellar clouds as the place for the prebiotic synthesis of the organic compounds necessary to life. The laws of thermodynamics require that a certain minimum temperature be reached before the synthesis of a given compound can happen. Generally the minima for interesting organic compounds are higher than the temperatures of the interstellar clouds.

In the Oct. 13 NATURE, V. I. Goldanskii of the Institute of Chemical Physics of the Academy of Sciences of the USSR in Moscow suggests a way around the problem. Goldanskii invokes quantum mechanics to permit what classical physics and chemistry prohibit, particularly the phenomenon known as quantum mechanical tunneling.

Tunneling is best understood by reference to the wave nature of matter. One of the fundamental and philosophically very difficult yet experimentally verified paradoxes of quantum mechanics is that every material body can be regarded simultaneously as a particulate object and as a packet of waves. Often the waves are regarded as measuring the probability of the particle being in a given place.

If one examines a wave of light striking an opaque substance, one finds that, although most of the wave is reflected, part penetrates into the opaque substance where it is absorbed. If the opaque material is thin enough, some of that penetrating wave will get all the way through, and light will appear on the other side. Similarly electrons will "tunnel" through a normally insulating material. Electron tunneling is exploited in a number of devices. What Goldanskii proposes is that whole atoms can tunnel in the same way through the barrier represented by the repulsive forces of other atoms and compound with them even though they do not have the energy (temperature) required by classical chemistry to overcome the repulsion. He has published papers in the past to show that such tunneling is possible.

Now Goldanskii calculates that such compounding by tunneling, though rare compared to classical chemical processes, could provide, in the lifetimes of the clouds, appreciable amounts of prebiotic compounds. Furthermore, significant numbers of them will survive the hazard of dissociation by ultraviolet light. Eventually a cloud is supposed to collapse to form a star and planets. Some of the matter in the outer parts of the cloud will never be heated enough to dissociate the compounds, and so some planets will appear endowed with the raw materials of life by their parent cloud. □

Tranquilizers may sustain alcoholism

Alcoholism, a formidable health problem in the United States, is often treated with diazepam (Valium) or related tranquilizers. Such treatments, it is claimed, help alcoholics "dry out" or withdraw from their addiction. But now experiments with animals suggest that instead of helping to lessen the alcoholic craving, diazepam and related drugs may actually sustain it.

J.A. Deutsch and Nancy Y. Walton of the University of California at San Diego studied the effects of diazepam on alcoholism in 32 rats. The rats were housed singly in clear cages with sawdust-covered floors. Food and water were freely available. All of the rats had tubes implanted in their stomachs and were then allowed to recover for a week in their cages.

The rats were divided into four groups.

Groups one and two were given alcohol (95 percent alcohol in water) through their gastric tubes every six hours for seven days. The daily alcohol dosage was increased by 1 gram per kilogram of body weight each day, from a dosage of 6 g per kg on day one to a dosage of 10 g per kg on day five. The 10 g per kg dosage level was then repeated on the last two days of alcohol intubation. At the end of this week, all of the rats were thus assumed to be alcoholics since rats given alcohol in this manner usually show a greatly increased tendency to select alcohol in a free-choice situation. In contrast, rats in groups three and four were only given water through their stomach tubes in order to serve as experimental controls. Water was then removed from all of the rats' cages although food continued to be available.

Rats in groups one and three, half of those that had become addicted to alcohol and half of those that had not, were given diazepam prior to each of eight choice-test sessions. Rats in groups two and four, the other half of the animals that had become addicted to alcohol and the other half that had not, were given water instead of diazepam before each of the same eight test sessions. During these experiments, all four groups could select either a flavored water solution or a flavored alcohol solution.

Throughout the tests, the four groups did not differ significantly in their drinking of the flavored water solution, although there were marked individual variations within the same groups. This finding ruled out the possibility that there might be overall thirst differences among the four groups—a situation that could have invalidated subsequent test results.

Some of the results were expected. Rats in groups one and two—those that had become addicted to alcohol—drank more alcohol than did rats in groups three and four (those that had not become addicted). Rats in group two became, like those in group four, low in alcohol consumption, indicating that their alcohol addiction was wearing off. Rats in group three also consumed little alcohol, showing that diazepam treatment in nonalcoholic rats has no influence on alcohol craving. These findings, too, the investigators expected. However, rats in group one, addicted rats that had been treated with diazepam, continued to drink a lot of alcohol. The investigators had expected opposite results—that diazepam would facilitate alcohol withdrawal in these animals.

Diazepam and related drugs thus appear to maintain the alcoholic state, not to diminish it. This suggests that the use of such drugs to treat human alcoholics may be counterproductive. "Such a result, if confirmed at the clinical level, has important implications for the pharmacological treatment of alcoholism," the researchers conclude in the Oct. 21 SCIENCE. □

Radio interferometer with satellite link

Interferometry is a technique for combining radiation received from a given source at two (or more) telescopes so as to obtain data with a spatial resolving power equal to that of a single telescope as large as the distance between the two receivers. With interferometry an astronomer can obtain details about the structure of a given celestial object that a single telescope would never reveal.

Resolving power depends on wavelength and, because radio waves are much longer than light waves, the quest for better resolution in radio astronomy quickly outran the size of the largest possible single radio mirrors. For a long time radio interferometers were limited to telescopes that could be physically connected (by cables or guided radio waves), because it is essential to combine signals received by the separate telescopes at the same instant.

About ten years ago improvements in atomic clocks made it possible to record the signals received by different telescopes and compare them later. This meant that interferometers could be set up using telescopes on opposite sides of the earth. In fact this has been done numerous times, and the technique of very long baseline interferometry (VLBI) has provided most of what is known about the fine structure of distant radio sources, especially the quasars and radio galaxies that have started serious controversies in astrophysics and cosmology. However, VLBI with recordings suffers from serious drawbacks. A way to escape these drawbacks and restore real-time data combination to VLBI has now been successfully tested and is reported in the Oct. 21 SCIENCE.

The technique involves using a geosynchronous (sometimes called geostationary) satellite as the link in the communications channel between the telescopes. The test case used the Hermes or Communications Technology Satellite, which had been put up as a joint Canadian-American program for communication with remote places. The first test was run in November 1976 using a telescope at the National Radio Astronomy Observatory in Green Bank, W. Va., and one at the Algonquin Radio Observatory at Lake Traverse, Ont. In May 1977 a second test, this time with a transcontinental baseline, was run between the Ontario telescope and one at the Owens Valley Radio Observatory in California. The astronomers involved include J. L. Yen of the University of Toronto, K. I. Kellermann and Benno Rayhrer of NRAO, N. W. Broten and D. N. Fort of the Herzberg Institute of Astrophysics in Ottawa, S. H. Knowles and W. B. Waltman of the Naval Research Laboratory in Washington, and G. W. Swenson Jr. of the University of Illinois at Urbana-Champaign.

A number of the current difficulties with VLBI are traceable directly to the necessity of recording the signals and the limitations of the recording devices. Comparison of the tapes must be done by a specialized computer, and this often takes more time than it took to make the observations, especially when more than two telescopes are used in a "multibaseline" observation. Time lags between recording and processing can run to several months.

Recording means that the observers lack continuous information on telescope performance during the observations so that undetected flaws can waste a lot of effort. It also means no access to the data as they come in. Sometimes knowing what is coming in can lead to important program changes while the observations are in progress. Tapes also impose a limitation on the waveband of the signals that can be observed that is narrower than the telescopes or a satellite transmission link can handle.

All these difficulties can be removed through real-time communication via satellite. A future prospect is the development of a phase-coherent interferometer, one in which the phase of the waves in each signal is known. That would remove certain ambiguities from the results, ambiguities that have contributed heavily to current astrophysical controversies. □

'Interim' policy for spent nuclear fuel

Almost 20 years after the first commercial nuclear reactor began operation, the United States is still without an agreed-upon means of permanently storing high-level nuclear wastes. The Energy Department, like its predecessor agencies, has promised that a decision on ultimate disposal of nuclear wastes—how and where to store them for the next 10,000 years—is only a few years away. Few are holding their breaths to see whether DOE meets that deadline, however, except electric utilities operating nuclear plants. For them the subject of permanent disposal is more than academic. Their capacity for storing spent fuel on site is dwindling; some are only two or three years away from filling to capacity. These plants will have to shut down if new storage is not found.

With this impending crisis in mind, President Carter offered last week to temporarily alleviate the problem by permitting the federal government to take possession of and title to commercial spent fuel on a voluntary basis. Utilities may turn over spent fuel to a government-owned repository for a fee which is now estimated to run about $100 per kilogram. (A 1,000-megawatt nuclear plant produces about 6,000 kilograms [30 tons] of spent fuel annually.) The one-time cost should also cover