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.