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SELF ASSEMBLY PROPERTIES OF PRIMITIVE ORGANIC COMPOUNDS

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A central event in the origin of life was the self-assembly of amphiphilic, lipid-like compounds into closed microenvironments. If a primitive macromolecular replicating system could be encapsulated within a vesicular membrane, the components of the system would share the same microenvironment, and the result would be a step toward true cellular function. The goal of our research has been to determine what amphiphilic molecules might plausibly have been available on the early Earth to participate in the formation of such boundary structures. To this end, we have investigated primitive organic mixtures present in carbonaceous meteorites such as the Murchison meteorite, which contains 1-2 percent of its mass in the form of organic carbon compounds. It is likely that such compounds contributed to the inventory of organic carbon on the prebiotic earth, and were available to participate in chemical evolution leading to the emergence of the first cellular life forms.

We found that Murchison components extracted into non-polar solvent systems are surface active, a clear indication of amphiphilic character (Deamer and Pashley, Origins of Life and Evolution of the Biosphere 19 (1989) 21-33.) One acidic fraction self-assembles into vesicular membranes that provide permeability barriers to polar solutes. Other evidence indicates that the membranes are bimolecular layers similar to those formed by contemporary membrane lipids. We conclude that bilayer membrane formation by primitive amphiphiles on the early Earth is feasible. However, only a minor fraction of acidic amphiphiles assembles into bilayers, and the resulting membranes require narrowly defined conditions of pH and ionic composition to be stable. It seems unlikely, therefore, that meteoritic infall was a direct source of membrane amphiphiles. Instead, the hydrocarbon components and their derivatives more probably would provide an organic stock available for chemical evolution. Our current research is directed at possible reactions which would generate substantial quantities of membranogenic amphiphiles. One possibility is photochemical oxidation of hydrocarbons. For instance, we have found that pyrene, a major polycyclic aromatic hydrocarbon of carbonaceous meteorites, acts as a photosensitizer in the hydroxylation of long chain hydrocarbons. This reaction is significant, in that a non-polar species (the hexadecane) becomes a surface-active molecule which would be available to partake in membrane formation.