# THE EVOLUTIONARY POTENTIAL OF SIMPLE ORGANIC CATALYSTS

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Evolution by mutation and natural selection apparently requires code-carrying macromolecules and template-directed replication. But much simpler molecules can in principle multiply autocatalytically, and these could explain the origin of life if natural selection could operate without a mutating linear code.

This unorthodox route to the origin of life requires, first, a simple organic catalyst that facilitates a rate-limiting reaction in the sequence leading to its synthesis (Calvin, 1956). This phenomenon has not been demonstrated unequivocally, but at least one likely example has been proposed. The phosphorylation of AMP to ATP is controlled *in vivo* by two enzymes. The first step is a dismutation between AMP and ATP:

$$AMP^{2-} + ATP^{4-} \rightleftharpoons 2ADP^{3-}$$

The second step, carried out *in vitro* with carbamyl phosphate by Saygin, (1981), converts both molecules of ADP to ATP. Ideally AMP would not react directly with the phosphate donor, but a single molecule of ATP would start the reaction by generating ADP. ATP would then increase exponentially as long as the concentrations of AMP and carbamyl phosphate remained adequate. This reaction illustrates the fact that dismutations in general may have a capacity for autocatalytic synthesis.

It has long been assumed that the early ocean would accumulate nutrients until life appeared, but such a solution would be susceptible to infection by a self-reproducing simple organic catalyst. If it catalyzed a general reaction, this process might change the chemical character of the ocean completely.

Granting the possibility of such reactions, how can they support evolution by natural selection? If one autocatalytic synthesis is likely, then a second, independent of the first, is not much less likely, and a third and a fourth. By increasing the complexity of the solvent mixture, each catalyst would make new reactions possible and hence new catalysts. A very effective catalyst would eliminate its competitors, and combinations that interacted cooperatively would enhance overall productivity. It appears that evolution could continue indefinitely in this mode, producing more and more complex metabolism until the system started to synthesize macromolecules capable of true mutation.

In Oparin's conception of chemical evolution natural selection operated among droplets, but his molecules could not multiply themselves so his droplets could not reliably transmit chemical properties to daughter droplets. Under control of organic catalysts the key molecules could migrate into new droplets in the same or new combinations. Natural selection would thus operate not among droplets but among catalysts, favoring those that stabilized droplets in which they could multiply. Information would be accumulated or integrated in an ecosystem or in the ocean rather than in single macromolecules (Allen,1988).

Allen, G.: 1988, Origins of Life 18, 289.

Calvin, M.: 1956, American Scientist 44, 248.

Saygin, O.: 1981, Naturwissenschaften 68, 617.