ON THE EVOLUTION OF PRIMITIVE CELLS IN ARCHAEAN SUBMARINE HOT SPRING ENVIRONMENTS : THE EMERGENCE OF ARCHAEBACTERIA, EUBACTERIA AND EUCARYOTES

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The submarine hot spring hypothesis for the origin of life (Corliss, et al., 1981; Corliss, 1986) suggests that Darwinian evolution began with the selection of classes of the most rapidly growing and replicating primitive cells within small steady-state flow reactors in the upper parts of Archaean submarine hot springs. The evolution of species began as these classes of cells diverged and adapted to the variety of environments within the hot springs and on sea floors surrounding their vents. Given this model for the first species we can search for the connections with research which follows the evolutionary tree from modern organisms back to its roots:

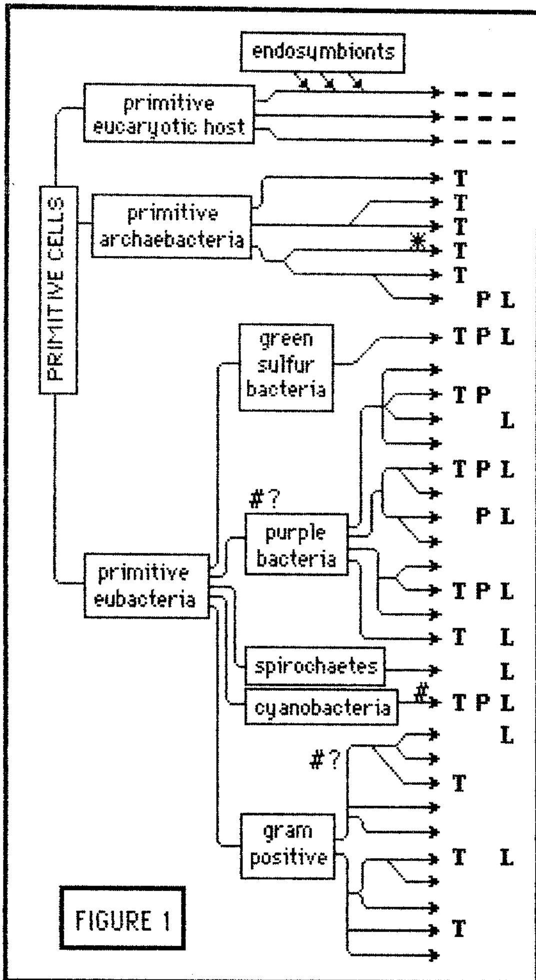
(1) The genealogy of modern bacteria (Fig. 1) determined by studies of the translation mechanism, e.g. ribosomal RNA sequence homologies (Fox, et al., 1980, Woese and Fox, 1977), suggests that living organisms diverged into into three distinct lineages at a very early stage; (1) archaebacteria, (2) eubacteria, and (3) the nuclear-cytoplasmic lineage of eucaryotic cells. Doolittle (1980) suggests that this divergence occured "at a time when problems of efficiency, speed and accuracy of translation were incompletely solved" so that the record of the process of divergence is not preserved in modern organisms.

(2) The hot spring affinities of several modern chemosynthetic archaebacteria suggest that they are the direct descendents of the first primitive hot spring organisms.

(3) The adaptation of these primitive submarine hot spring organisms to the surface environment most likely occured at an interface between these two environments, where reducing hot spring fluids diffusing vertically through sediment meet oxidized sea water at the sediment-water interface, to form a redox gradient (Fig. 2). Such a gradient provides a variety of redox reactions suitable for mediation by micro-organisms, to create a hydrothermal laminated microbial community [LMC](Krumbein, 1983). In shallow water, such an LMC would also be subject to a flow of radiant energy from the sun. Fossil LMC's, the stromatolites, form the dominant record of life on earth for the first 75% of its history (see Byerly, et al., 1986).

(4) Fox, et al. (1980) describe some general characteristics of the eubacteria (Fig. 1): (a) the oldest groups are basically anaerobic (the clostridia, the purple photosynthetic bacteria, the cyanobacteria), (b) aerobic respiration arose later, and independently in several groups, (c) photosynthetic lines are intermixed with non-photosynthetic, and (d) the major eubacterial groups diverged over relatively short time. All major lines of eubacteria include dwellers in modern LMC's. I suggest that hydrothermal LMC's in shallow Archaean seas formed the context in which chemosynthetic primitive cells from underlying hot springs learned the variety of metabolic pathways the eubacteria exhibit today. During this evolution, transitional forms were outcompeted by the surviving forms, and the modern archaebacteria were left, in extreme environments, as isolated remnants of a diverse primitive fauna.

(5) Thermophilia is widespread in bacteria (Fig. 1). Brock (1985) suggests that since the evolutionary path from thermophilic to mesophilic organisms is easy, while evolution to thermophilia is very difficult, the ancestors of all living organisms were thermophilic.



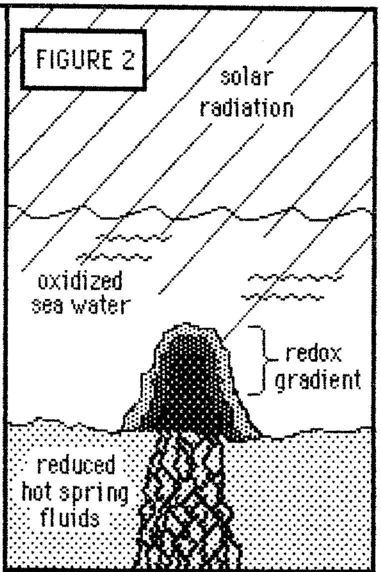


Figure 1. Evolution from primitive cells to the three kingdoms (modified from Fox, et al., 1980) **T** = thermophilic, **P** = photosynthetic, **L** = laminated microbial communities, ✱ = proposed eucaryotic host, # = proposed eucaryotic endosymbionts.

Figure 2. A hypothetical solar/thermal laminated microbial community on the floor of a shallow Archaean sea.

(6) Hydrothermal LMC's were the first ecosystems, in which organisms began to modify their own environment and began to adapt to these modifications. The extension of these symbiotic relationships to the creation of the first eucaryotic cells (Margulis, 1981), must have occured within solar-thermal LMC's. Typical photosynthetic LMC organisms are proposed endosymbionts, and a hot spring archaebacteria is suggested as the host cell (Searcy, 1982).

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