THE FORMATION OF LIFE

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ABSTRACT

The formation of life is an automatic stage in the consolidation of rocky or "terrestrial" planets. The organic (=carbonaceous) matter, light elements, gases, and water must "float" toward the surface and the heavier metals must sink toward the center. Random processes in the molecular soup that fills microfractures in the crust eventually produce self-replicating microtubules.

Planetesimals coalesce into a planet and consolidate into a solid body with a hot interior. The organic (=carbonaceous) matter, light elements, gases, and water must "float" toward the surface and the heavier metals must sink toward the center. Let there be planetesimal material in the crust that has remained unmelted, and let there be cooled melted crust. Both are brittle and full of fractures, microfractures, and voids down to the level where the internal temperature softens the rock and closes microfractures, say ten kilometers.

The whole ten-kilometer surface layer of this crust fills with organic soup charged with gases. The crust acts as a high pressure reaction vessel in which preexisting chondritic material breaks down into molecular soup in which new organic molecules can form in great variety. The microfractures are lined with crystals that provide catalytic scaffolding on which molecular films can grow. There are numerous randomly-formed molecules that have large representations in the soup. All the possible combinations of interactions between the multiple kinds of crystal surfaces and the numerous kinds of organic molecules are automatically tried by the soup. Longish molecules that are hydrophilic on one end and hydrophobic on the other and have a "diameter" that is a multiple of the crystal spacing can form a monolayer with the molecules aligned side by side with the hydrophylic ends weakly bonding to the crystal surface and with the hydrophobic ends quasi-replicating the crystal surface as in Figure 1. If the crystal structure is not rectilinear, the structure of the film is not rectilinear. The edges where the film is growing can be stepped or ragged.

All the possible combinations of interactions between the new monolayer surfaces and the numerous kinds of organic molecules are automatically tried by the soup. Some molecules work and attach to the hydrophobic ends and to each other. They produce a bilayer that is stable and whose surface quasi-replicates the crystal.

The microfractures are not a quiet environment. There are earthquakes, impacts, sudden flows of soup, bubbles, etc that dislodge the bilayers from the crystal faces. Free in the soup, the bilayers curl with the hydrophobic face on the inside. The edges can curl together and, if opposite edges fit together, bind into microtubules. They become bilayer cylinders with hydrophilic outer surfaces and hydrophobic interior surfaces. Soup flows through and over the microtubules. Bilayers in the soup that do not form microtubules are recycled back into their constituent molecules. Some of the microtubules are made with combinations of molecular layers that are self-catalyzing and self-propagating. The bilayer edges continue to bind more molecules to both layers at both ends of the cylinder. The microtubules grow longer and longer. Eventually they mechanically break and each piece becomes a growing microtubule. Each microtubule created this way from a crystal template is a new self-replicating life form. The crust of the planet fills with microtubules. There are thousands of different kinds, each in a range of diameters that are accidentally determined. Life is automatically produced millions of times and automatically destroyed millions of times. Only the most fit microtubules survive and propagate. The rest eventually disintegrate back into the soup.

In Figure 1, the g molecule descenders all point the same way. If the original bilayer was made from chiral molecules, the microtubule descendents will all have the same chirality.

Each microtubule is a "catalytic converter" because its inner and outer surfaces have many well-spaced attachment points. A microtubule can hold two molecules from the soup in position while they bind together. A microtubule can "crack" or disassemble large molecules by holding one end so the rest can be attacked by the hot soup. A microtubule can make molecules and polymers that do not release but are bound to its wall. An elastic polymer would allow a microtubule to move in response to heat or pH. Or peristalsis would be possible to pump the soup through the tube to increase growth rates. Microtubules can bind to each other and can form structures.

There are, say, 10^{12} generations in the first billion years. Since the original microtubules are made by random processes, they do not have the optimal design, and they especially do not have the optimal design when the microfracture environment changes. At the growing ends of the microtubules, a molecular substitution can be made if other molecules will bind into that space. Alternation patterns may develop. The random processes also test all possible isotopomeric substitutions. The new molecule can be a "dud" that truncates growth in that position. The microtubule grows narrower. If it happens a few times the whole end of the microtubule becomes closed. The new substitute molecules may bind more strongly or less, faster or slower, strengthen or weaken the backbone. Changes that make the microtubule more fit will be adopted. If the change makes a whole bilayer row grow faster, that row can stick out of the end of the microtubule as a microribbon. Eventually the ribbon breaks off the microtubule to form a free-floating microribbon, a one-dimensional microtubule. Microribbons can bind to microtubules and have replicating and catalyzing capability. The microribbons spread throughout the crust.

All of this is independent of conditions on the surface of the crust which can be covered with ices, or liquids, or gases, or nothing. In the microfractures, microtubules and microribbons are protected from stellar radiation. They are warmed from below by consolidation and radioactivities. They are damaged by radioactivities in the crust, but microtubules are resistant because of their interlocking structure, and they can continue to grow even when damaged. As the radioactivities decay and cool, the microtubules and microribbons discover new ways of modifying their environment to generate energy. Life can continue in the microfractures even if the original unmelted crust is destroyed. Life becomes more and more complex and may eventually spread from the interior of the crust to the surface as well.

In some environments self-assembling membranes encapsulate assemblages of microtublules and microribbons. Microribbons evolve into RNA and DNA. Membranes evolve into cell walls. Microtubules evolve into channels through the cell walls, into cellular molecular processing factories, and into structural microtubules. Life becomes cellular life.

Figure 1. A bilayer film seen through the crystal face on which it formed. Molecule AK has a hydrophilic end A that binds to the crystal in a regular pattern and a hydrophobic end K. Molecule g binds to the K end of AK and to other g molecules to repeat the pattern and strengthen the film. When the film is peeled off the crystal it can sometimes curl into a microtubule.