On Molecular Natural Selection and Abiogenesis

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EVOLUTION BY NATURAL SELECTION AND COOPERATION is now firmly regarded by many people, myself included, as a viable natural explanation for the resplendent radiation of life on Earth. For them, evolution has shifted any serious consideration for the working of a Hand of God to some $3\frac{1}{2}$ billion years ago when the molecular beginnings of life first took hold on Earth.

Abiogenesis [1] is concerned with these molecular beginnings. Theists often argue against abiogenesis being a natural one. Perhaps it is because a viable explanation of a natural abiogenesis would serve to push the miraculous workings of the Hand of God further back in time, thereby further closing the window of their gods' supernatural presence and intervention in peoples' lives. The study of natural abiogenesis does not presume the existence of an intervening Hand of God. Instead, it holds that the beginnings of life occurred naturally.

Natural abiogenesis must of course be predicated on a propensity for Earth's systems to form complex molecular structures. These structures must be able to persist and grow over time and space. I propose four natural prerequisites for such complexity to take root spontaneously in a natural system without a Hand of God, and hence, for a natural abiogenesis to occur spontaneously on Earth without an Intelligent Designer.

Prerequisites for spontaneous emergence of complexity.

1. *A reliable source of low entropy.*[2] (∇)

   This source provides a sustained entropy gradient for the system as a whole. The entropy gradient is the impetus for change of state in the system. That is, it is the impetus for motion, and for molecular re-arrangement. It is impetus for surprise at the molecular scale. It is the impetus for complexification.

   Change in the system always climbs the entropy gradient towards increasing entropy, i.e., toward increasing disorder. That is, if there were to be no entropy gradient, there would be no change.

   For the Earth as a whole, this low entropy has two sources. The first and primary source is the incident radiation from the sun in the form of a regular daily stream of high-energy density photons. The second source is radiogenic heat energy produced by the radioactive decay of isotopes in the Earth's mantle and crust. ( )

2. *Autonomous agents for interaction.* ($\rightleftharpoons$)

   Qualitatively different types of autonomous agents are needed, with each type equipped with various ways of interacting. The agents, with their many possible interactions, allow for many equivalent ways for the system to change. This leads to many opportunities for bifurcation.[3]

   On Earth, chemical elements and organic elements in particular, such as carbon, nitrogen, oxygen and sulfur evidently suffice as these autonomous agents. And their covalent bonds, together with some ionic bonds, suffice as the required ways of interacting. ( )

[1] *Abiogenesis*—A term signifying the production of life without life to begin with.

[2] *Entropy*—The measure of a system's thermal energy per unit temperature that is unavailable for doing useful work. Because work is obtained from ordered molecular motion, the amount of entropy is also a measure of the molecular disorder, or randomness, of a system.

[3] *Bifurcation*—The division of something into two branches or parts.

3. *A state of persistent non-equilibrium.* ()

   The overall cooling of the nascent Earth, igneous activity, the Milankovitch cycles, changing landmasses, extraterrestrial impact events, changing climate, weather patterns, diurnal insolation, and temperature fluctuations, all contribute to a state of persistent non-equilibrium. ()

4. *Time and space.* ()

In a pre-biotic world, competition and cooperation selection pressures could not have been driving forces behind biotic survival. But with these four prerequisites present in a natural system, these two pressures would have emerged naturally and spontaneously at a molecular scale, thereby constituting a pre-biotic *molecular natural selection.* ()

Molecular natural selection. So what do I mean by molecular natural selection? The existence of many interacting agents and of many types of agents (Prerequisite 2) allow for many random and equivalent ways of climbing the entropy gradient (Prerequisite 1). Occassionally and capriciously, one such climb may become enhanced in direct proportion to the climb itself. This is a spontaneous feedback. In other words, as a subset of interacting agents climb the entropy gradient, their way of climbing becomes more "popular" precisely because of the climb itself. A trodden path becomes a well-trodden path. ()

Some ways of climbing the entropy gradient will therefore tend to stabilise and grow. But confronted with the state of non-equilibrium (Prerequisite 3), these climbs will face a trade-off. On the one hand, their very existence will tend to stabilise and increase their popularity. But on the other hand, the state of non-equilibrium will disrupt them. This tension will tend to promote bifurcation, thereby increasing system complexity, whilst all the while climbing the entropy gradient. Increasing complexity in this way implies an increase in molecular complexity. This, then, is molecular natural selection. ()

Molecular natural selection offers a plausible foundation for natural abiogenesis. Firstly, the foundation relies on system prerequisites which are at once sensible and natural, as I listed above. And secondly, the overall driving force is simply that there be many energetically equivalent ways in the system for climbing the entropy gradient. Indeed, this is exactly what we see playing out to this day. ()

In closing. The gradient of increasing entropy provides an impetus needed for the agents to interact over space and time, and to adapt with increasing complexity to the overall system's state of persistent non-equilibrium.

In other words, on Earth, both solar insolation and radioactive isotopic decay imposed a thermodynamic gradient on the pre-biotic world, which in turn created an ongoing and random flurry of interaction between different molecular species. Some of these forms of interaction enjoyed a positive feedback effect, and others not, thus giving rise to a population selection pressure. But amidst the continual change and flux on Earth, new interaction pathways continually emerged. Some pathways were new, while others built on what came before. And so, slowly but surely—inexorably—over space and time, system complexity rooted and grew.

And thus was the foundation laid for the genesis of molecular natural selection, for molecular replication, for molecular complexification, and ultimately for the emergence of simple unicellular prokaryotic life forms.