Scientists propose the kind of chemistry that led to life

June 8 2007

Before life emerged on earth, either a primitive kind of metabolism or an RNA-like duplicating machinery must have set the stage – so experts believe. But what preceded these pre-life steps?

A pair of UCSF scientists has developed a model explaining how simple chemical and physical processes may have laid the foundation for life. Like all useful models, theirs can be tested, and they describe how this can be done. Their model is based on simple, well-known chemical and physical laws.

The work appears online this week in *The Proceedings of the National Academy of Sciences*.

The basic idea is that simple principles of chemical interactions allow for a kind of natural selection on a micro scale: enzymes can cooperate and compete with each other in simple ways, leading to arrangements that can become stable, or "locked in," says Ken Dill, PhD, senior author of the paper and professor of pharmaceutical chemistry at UCSF.

The scientists compare this chemical process of "search, selection, and memory" to another well-studied process: different rates of neuron firing in the brain lead to new connections between neurons and ultimately to the mature wiring pattern of the brain. Similarly, social ants first search randomly, then discover food, and finally build a short-term memory for the entire colony using chemical trails.

They also compare the chemical steps to Darwin's principles of evolution: random selection of traits in different organisms, selection of the most adaptive traits, and then the inheritance of the traits best suited to the environment (and presumably the disappearance of those with less adaptive traits).

Like these more obvious processes, the chemical interactions in the model involve competition, cooperation, innovation and a preference for consistency, they say.

The model focuses on enzymes that function as catalysts – compounds that greatly speed up a reaction without themselves being changed in the process. Catalysts are very common in living systems as well as industrial processes. Many researchers believe the first primitive catalysts on earth were nothing more complicated than the surfaces of clays or other minerals.

In its simplest form, the model shows how two catalysts in a solution, A and B, each acting to catalyze a different reaction, could end up forming what the scientists call a complex, AB. The deciding factor is the relative concentration of their desired partners. The process could go like this: Catalyst A produces a chemical that catalyst B uses. Now, since B normally seeks out this chemical, sometimes B will be attracted to A -- if its desired chemical is not otherwise available nearby. As a result, A and B will come into proximity, forming a complex.

The word "complex" is key because it shows how simple chemical interactions, with few players, and following basic chemical laws, can lead to a novel combination of molecules of greater complexity. The emergence of complexity – whether in neuronal systems, social systems, or the evolution of life, or of the entire universe -- has long been a major puzzle, particularly in efforts to determine how life emerged.

Dill calls the chemical interactions “stochastic innovation” – suggesting that it involves both random (stochastic) interactions and the emergence of novel arrangements.

“A major question about life’s origins is how chemicals, which have no self-interest, became ‘biological’ -- driven to evolve by natural selection,” he says. “This simple model shows a plausible route to this type of complexity.” Dill is also a professor of biophysics and associate dean of research in the UCSF School of Pharmacy. He is a faculty affiliate at QB3, the California Institute for Quantitative Biomedical Research, headquartered at UCSF.

Source: University of California - San Francisco

Citation: Scientists propose the kind of chemistry that led to life (2007, June 8) retrieved 2 May 2024 from https://phys.org/news/2007-06-scientists-kind-chemistry-life.html