The Evolution Prize:
Is Open-Ended Evolutionary Innovation in a Closed System Possible?

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Abstract

Astrobiology reveals that Earth's biosphere may be open to genetic input from elsewhere. How important is this potential input? Could life on Earth have originated and evolved to its current level of organized complexity without it? Is open-ended evolutionary innovation even possible in a closed system? The Astrobiology Research Trust (ART) desires to promote interest and research into this question. For a demonstration that provides an answer in artificial life, ART will award a prize of $100,000.

The Role of Artificial Life

Open-ended evolution is characterized by a continued ability to invent new properties — so far only the evolution of life on Earth (data partly from the fossil record) and human technology (data from patents) have been shown to generate adaptive novelty in an open-ended manner. — So said Norman Packard and Mark Bedau in 2003 (1). Of course human technology is an open system because it receives input from human agents. And with the advent of astrobiology, we now admit that Earth's biosphere also may receive genetic input from elsewhere. Therefore, the title question is not already answered by life on Earth or human technology.

Artificial Life offers the opportunity to explore closed-system evolutionary phenomena more quickly than real life. If Open-Ended Evolutionary Innovation (OEEI) in a closed system is possible, an artificial life model should be able to achieve a demonstration. ART wishes to stimulate this endeavor by establishing a prize for such a demonstration.

The Prize

If OEEI is possible, a demonstration should eventually succeed and the successful person or team will be awarded the prize. As a first step, ART wishes to identify committee members and jurors who are genuinely interested in the title question, and would be motivated to scrutinize carefully any submitted demonstrations. The jury that administers and judges the prize must be capable and impartial, both in fact and in public perception.

We hope that participants at the ALife X conference will begin to clarify the criteria for the prize, and consider how to administer it.

Definitions

Evolution. Evolution is an iterative process in which encoded instructions such as genotypes are executed to produce results such as phenotypes. The results include the instructions for the next generation, and these are varied by some mechanism. Once per generation, the results undergo natural selection. Repetition of this process changes both the instructions and the results in a cumulative manner.

Innovation. Innovation is nearly synonymous with invention and is most easily illustrated by example. In biology consider, "Origin of Earth's life,… Universal genetic code,... Nitrogen fixation, Aerobic respiration, Multicellularity,... Mineralized skeleton,... Animal muscularized appendages,... Image-forming eyes...." These are among 78 evolutionary innovations recently listed online in *PNAS* (2). Other lists may be found in *The Major Transitions in Evolution*, by Maynard Smith and Szathmáry (3), *The Material Basis of Evolution* by Richard Goldschmidt (4) and most biology texts. Examples of innovations in commercial computer applications (produced in an open system) are even easier to list.

Not Innovation. Innovation is also clarified by identifying phenomena that would not qualify. Some are:

Optimization: An existing program may be optimized in the manner of Richard Dawkins' Biomorphs (5), and in life, single nucleotide substitutions can optimize the color sensitivity range of retinal opsins. But optimization is confined to narrow ranges and does not innovate.

Puzzle solving: An existing program may exist in a few fragments which an operating system can piece together. For example, if the text of The Declaration of Independence were randomly cut into half-a-dozen pieces, the syntax- and spell-check features of a word processor might enable a computer to reassemble it correctly. In this manner a phenotype might exhibit an apparent innovation when, in fact, the instructions for it were preexisting. Similarly, if genes gain new capabilities when exons are inserted, this might exemplify only puzzle-solving. But the original composition of a given exon probably would constitute an innovation, and the origin of the capability to puzzle-solve definitely would qualify as an innovation.

Gene transfer and symbiosis: Functional genetic programs and even whole genomes may be transferred and merged. These processes illustrate acquisition, not innovation.

Goal seeking: Richard Dawkins explains how a given sentence from Shakespeare can evolve from a random sequence if the correct characters, once found, are preserved (6). This evolution is artificial or teleological, and the evolution of life is not.

Emergent properties: The "gliders" in Conway's Game of Life, and the images of fractal graphs may be called emergent properties. New kinds of gliders and new images may continue to be found in such models. But innovations must come from the iterative feedback between the instructions and the results. By definition, innovations must result from new instructions, not the original ones.

Program switching: Trypanosomes have more than a hundred different coat proteins from which they can select as needed to keep ahead of the host's antibodies (7). Switching them is not an innovation.

Beyond citing positive and negative examples, precisely defining innovation is difficult. Hopefully, conference participants will not be too daunted by this difficulty. Meanwhile, another term should help to make the present challenge clear:

Open-ended. If a model can achieve only one apparent innovation, after which additional innovations are not realized, nor even expected, the title question has not been answered. Assurance comes if the process continues without an obvious limit. This provision is important because deciding whether an apparent innovation actually is one may be difficult. A one-time phenomenon could be the result of mere optimization and puzzle-solving, for example. One could suggest, of course, that all innovations are produced like that. If so, the process does not halt after one debatable innovation, but produces more. Hopefully, the conference will add clarity here also.

Closed system. The system is closed if no additional instructions in any form, such as keystrokes, commands, viruses, patches, etc., are admitted after the evolutionary process begins. Energy in the form of electricity, sunlight or food, and materials such as air, water, paper or plastic may be supplied as the model requires.

System means not just the applications software, but includes the underlying computer operating system and any other software or hardware that might have any role in the process.

Discussion

A model purporting to demonstrate OEEI in a closed system must be carefully judged. A substantial prize will be at stake, but there is a more important reason. We may think that the challenge is simply to demonstrate something already known, but do we really know it? Closed-system biological models (8) have not yet demonstrated the phenomenon. Purely logical proofs rely too heavily on the big bang theory. Without direct evidence such as we are seeking here, it is reasonable to doubt that OEEI in a closed system is possible. Therefore, an important scientific issue is also at stake.

Regardless of the ultimate answer to the title question, science should not abandon scientific principles and adopt unscientific explanations. Yet many Darwinists on one side, and proponents of creationism/ID on the other, claim that only a positive answer can be treated scientifically. This false dilemma is detrimental to science.

References

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