In real or artificial life,

Is Evolutionary Progress in a Closed System Possible?

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Evolutionary progress in life on Earth is evident in the long series of steps that lead from prokaryotic life more than three billion years ago to the variety of multi-celled eukaryotic creatures with specialized organs, tissues, systems and features that exist here today. It is driven by the accumulation of new genes, the encoded instructions for life. We would like to understand this progress.

Of course, energy reaches Earth from the sun, but, encoded instructions do not. We have long believed that evolutionary progress takes place in a *biologically* closed system, because we thought, until recently, that life could not survive in space. We thought the whole planet was a closed biological system.

Today, it is no longer certain, nor even likely, that Earth's biological system is closed. We now know that cells can survive in space and could be delivered intact to Earth's surface (NASA, 1999). We now know that dormant bacterial spores can remain viable for at least 25 million years (Cano & Borucki, 1995); it is reasonable to suppose that they are immortal (Postgate, 1994). There is growing evidence that Mars once harbored bacteria, and that rocks containing them have reached Earth (McKay *et al.*, 1996).

Closed-system demonstrations of evolutionary progress in biology are not difficult in principle, but they have not been convincingly done. At this point, the biological case rests on the remotest evidence of all — the big bang. If the whole universe is a closed system that began in a lifeless state a finite time ago, then evolutionary progress, including the origin of life, must have subsequently happened in it. But the big bang theory is plagued with frequent surprises (*c.f.* Glanz, 1998), and in some important versions of it, big bangs are preceded by other big bangs *ad infinitum* (Guth, 1997). It is an immature theory with unknown implications for life. To understand evolutionary progress, biology should be able to rely on firmer and more immediate evidence.

Meanwhile, biologists are finding more and more evidence, like viral genes in humans (Sverdlov, 1998), indicating that the lateral transfer of genes is a ubiquitous process. The biological means to make evolutionary progress in an open system are becoming well known (Lake *et al.*, 1999).

With its basis weakened and an alternative apparent, the theory that life makes evolutionary progress in a closed system needs additional support.

Computers, like life, rely on encoded instructions. They also exhibit evolutionary progress. Accumulated improvements have made commercial hardware and software far more powerful today than only twenty years ago. Of course, this evolution has occurred in an open system, because people installed the improvements. But computer experiments that attempt to model evolutionary progress in closed systems are under way (*c.f.* Ray, 1996). The work is called "artificial life" and various other names, and the experimental environment is not restricted to conventional software. Obviously, a closed-system model that exhibited unmistakable evolutionary progress would have profound importance for biology. In fact, many closed-system computer models can exhibit surprising behavior or solve preestablished problems. But in spite of much honest effort, none has achieved lifelike evolutionary progress. They all remain confined within their original parameters.

Nevertheless, computer scientists are confident that an unquestionable demonstration of evolutionary progress in artificial life is imminent, because they think they are only trying to model a phenomenon already proven in biology. Many biologists, on the other hand, think computer models have already corroborated evolutionary progress in a closed system.

Yet the phenomenon has not been unequivocally demonstrated in either medium. Until it is, one can reasonably doubt that evolutionary progress in a closed system is possible, in real or artificial life.

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