

## The arrow of complexity hypothesis

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The evolution of the biosphere exhibits a trend of increasing complexity of the most complex organisms. Even though we are uncertain about the proper way to measure complexity, it is hard to deny the trend that the earliest prokaryotic cells are simpler than the eukaryotic cells that arose from them, and these were simpler than the multicellular life forms that evolved from them, and so on. But this trend is controversial to interpret and explain, and even to describe properly. Some think that the trend has for all intents and purposes already been explained. In contrast, I argue that the trend is not yet adequately explained but instead is a major remaining challenge in understanding the creativity of evolution.

Progress on this challenge is slowed in part because many people fail to realize that the explanation of life's complexity is still a mystery. Some people believe that natural selection given an infinite space of genetic possibilities will inevitably produce more and more complex adaptations. But soft artificial life models like Tierra, Avida, and Echo show conclusively that those mechanisms are in general insufficient to produce a trend of increasing complexity. The proof is simple: The models embody those mechanisms but they don't exhibit the requisite behavior. Mechanisms like natural selection in an infinite space of genetic possibilities might be necessary for explaining the trend, but they are not sufficient.

This implies that we need new concepts, theories, and models if it is to resolve the arrow of complexity hypothesis. Fortunately, soft artificial life models can be just the right tool for exploring answers to this question. But these models are not fool-proof. Some models beg the interesting questions, and others fail to produce the relevant behavior. So, proper use of these models requires care and experience. But in the right hands, they can provide a public, repeatable, and empirically grounded method for making incremental progress on the question of the creativity of evolution.