

The Darwinian Interlude

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Biotechnology will do away with species. Good: cultural evolution is better than natural selection.

By Freeman Dyson

Carl Woese published a provocative and illuminating article, "A New Biology for a New Century," in the June 2004 issue of *Microbiology and Molecular Biology Reviews*. His main theme is the obsolescence of reductionist biology as it has been practiced for the last hundred years, and the need for a new biology based on communities and ecosystems rather than on genes and molecules. He also raises another profoundly important question: when did Darwinian evolution begin? By Darwinian evolution he means evolution as Darwin himself understood it, based on the intense competition for survival among noninterbreeding species. He presents evidence that Darwinian evolution did not go back to the beginning of life. In early times, the process that he calls "horizontal gene transfer," the sharing of genes between unrelated species, was prevalent. It becomes more prevalent the further back you go in time. Carl Woese is the world's greatest expert in the field of microbial taxonomy. Whatever he writes, even in a speculative vein, is to be taken seriously.

Woese is postulating a golden age of pre-Darwinian life, during which horizontal gene transfer was universal and separate species did not exist. Life was then a community of cells of various kinds, sharing their genetic information so that clever chemical tricks and catalytic processes invented by one creature could be inherited by all of them. Evolution was a communal affair, the whole community advancing in

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metabolic and reproductive efficiency as the genes of the most efficient cells were shared. But then, one evil day, a cell resembling a primitive bacterium happened to find itself one jump ahead of its neighbors in efficiency. That cell separated itself from the community and refused to share. Its offspring became the first species. With its superior efficiency, it continued to prosper and to evolve separately. Some millions of years later, another cell separated itself from the community and became another species. And so it went on, until all life was divided into species.

The basic biochemical machinery of life evolved rapidly during the few hundred million years that preceded the Darwinian era and changed very little in the following two billion years of microbial evolution. Darwinian evolution is slow because individual species, once established, evolve very little. Darwinian evolution requires species to become extinct so that new species can replace them. Three innovations helped to speed up the pace of evolution in the later stages of the Darwinian era. The first was sex, which is a form of horizontal gene transfer within species. The second innovation was multicellular organization, which opened up a whole new world of form and function. The third was brains, which opened a new world of coordinated sensation and action, culminating in the evolution of eyes and hands. All through the Darwinian era, occasional mass extinctions helped to open opportunities for new evolutionary ventures.

Now, after some three billion years, the Darwinian era is over. The epoch of species competition came to an end about 10 thousand years ago when a single species, *Homo sapiens*, began to dominate and reorganize the biosphere. Since that time, cultural evolution has replaced biological evolution as the driving force of change. Cultural evolution is not Darwinian. Cultures spread by horizontal transfer of ideas more than by genetic inheritance. Cultural evolution is running a thousand times faster than Darwinian evolution, taking us into a new era of cultural interdependence that we call globalization. And now, in the last 30 years, *Homo sapiens* has revived the ancient pre-Darwinian practice of horizontal gene transfer, moving genes easily from microbes to plants and animals, blurring the boundaries between species. We are moving rapidly into the post-Darwinian era, when species will no longer exist, and the evolution of life will again be communal.

In the post-Darwinian era, biotechnology will be domesticated. There will be do-it-yourself kits for gardeners, who will use gene transfer to breed new varieties of roses and orchids. Also, biotech games for children, played with real eggs and seeds rather than with images on a screen. Genetic engineering, once it gets into the hands of the general public, will give us an explosion of biodiversity. Designing genomes will be a new art form, as creative as painting or sculpture. Few of the new creations will be masterpieces, but all will bring joy to their creators and diversity to our fauna and flora.

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Advanced Study in Princeton, NJ. His research has focused on the internal physics of stars, subatomic-particle beams, and the origin of life.