THE BIOLOGOS FOUNDATION

What is evolution?

Introduction

Evolution means a change over time. For example, laptop computers have evolved in the last decade. However, when biologists discuss evolution, they are referring to the entire history of life. Specifically, biological evolution refers to the development of ancestral species into current diverse species.[1] The slow process of evolutionary development comes about through changes in DNA, or mutations, which fundamentally change the biology of the organism. When those changes are favorable to survival, they are preserved. If a population of some species undergoes a substantial number of such changes — and is geographically isolated from other related populations — a new species may appear.

Descent from Common Species

A cardinal principle of biological evolution is that all living things descended from earlier, less advanced ancestral species. These first free-living organisms are believed to have appeared on Earth about 3.85 billion years ago, making some of the early details of evolution a mystery. As a result, the actual origin of life remains unexplained, and evolutionary theorists do not attempt to

explain it. These original organisms, however, carried information and were capable of self-replication. Over very long periods of time, nature's selection for beneficial mutations — as well as nature's selection against detrimental mutations — has led to the vast diversity of living things that exists today.

Gene Mutations and Physical Variations

In his book *The Origin of Species*, Charles Darwin notes that when any species reproduces, the newly created organism has slight physical variations from its predecessor. Although Darwin did not know it at the time, these physical differences were a consequence of variation in the DNA. The types of changes found in a single generation are usually due to a reshuffling of the organism's pre-existing gene variation. However, over longer periods of time, new mutations in DNA can result in the appearance of novel features. These mutations in the DNA subtly favor certain features, although they appear to develop randomly. Again, it is these variations that can cause a change in the biology or physical attributes of the organism.

Nature's Method of Selection

A second theme in Darwin's work is the idea that all species struggle for survival. Throughout nature, there is an evident competition for life-sustaining resources, as well as a struggle to avoid becoming the nourishment for another organism. The random variations with which an organism comes into the world can either help or hinder that organism in its struggle for survival. Most mutations are actually harmful, but organisms that inherit a rare beneficial trait are more likely to reproduce than other organisms, which gives rise to even more organisms with those same traits. This struggle for survival is the method by which nature selects certain traits.

More recently, it has been proposed that evolutionary selection may not have been based solely upon the struggle for survival of individual organisms. There is also an awareness that a group of organisms could sometimes benefit from its members behaving in ways that would otherwise be detrimental to an individual organism. This is called group selection, which takes into account the survival needs of an entire community of a given species. In a community, certain traits or behaviors that would be naturally selected for a species of individual organisms could potentially be detrimental to the group. For example, high reproduction rates are normally advantageous for the evolution of a species whose members live in relative isolation. However, for a species whose members live in communities, very high reproduction rates could lead to problems for the group, like a diminishing food supply. In such a situation, communities whose members had more modest reproduction rates would be more likely to survive.

Inheritance

The inheritance of physical characteristics is the crux of natural selection. There would be no possibility for such significant change over time if beneficial traits were not passed on from generation to generation. When Darwin published *The Origin of Species*, the inheritance of traits was poorly understood. More than a quarter of a century passed before the rediscovery of Gregor Mendel's work provided mathematical specificity for the units of inheritance. And it was not until the mid 20th century that Mendel's research was finally synthesized with Darwinian evolution. Their union gave rise to a more complete theory of evolution called Neo-Darwinian evolution.[2]

Speciation

A common argument raised against the theory of evolution is that despite hundreds of years of observation, there has been no experimental proof of macroevolution. Scientists have only directly followed minor microevolutionary changes, and primarily within a single species. Some prominent examples of microevolution include the variation of finches' beaks in the Galapagos Islands, or the variation of dogs' body types in societies that breed them.[3] In these cases, the result of gradual changes has only amounted to a new form of the same species.

The distinction between microevolution and macroevolution is somewhat arbitrary. After all, macroevolution involves nothing more than a long series of microevolutionary changes within a particular species until those changes become significant enough that they prevent interbreeding within that species. According to the above definition of species, this calls for a new name. This is especially true when one considers the possibility of geographical separation over long periods of time. If, during the slow process of microevolutionary changes, a species becomes divided by some geographical barrier like a river or a mountain, the different factors of the two environments may encourage different traits to be inherited by future generations. With enough time, macroevolutionary changes leading to speciation can occur.

Many still wonder why macroevolutionary changes have never been observed. The simple answer, as Darrel Falk puts it, is that we haven't been watching long enough.[4] The types of genetic mutations that eventually lead to macroevolutionary changes are rare, and this accounts for the slow pace of evolutionary development. The amount of time that we have spent observing nature is only a tiny fraction of the evolutionary timescale. Moreover, the evolutionary process cannot be expedited by selective breeding within a species. To breed dogs with dogs, for example, will mostly result in a re-shuffling of the information that is already present within the canine genes of that

population. If there is a certain trait, like size or color, that is already present within the genes, then selective breeding opens the possibility of making that feature more prevalent within the population. However, selective breeding does not accelerate the rate of genetic mutations that occur in each generation. Because those novel mutations are rare but represent necessary steps toward evolutionary change, selective breeding will not speed up the process of macroevolution.

Misconceptions

The claim that humans share a common ancestry with other species should not be misunderstood to mean that humans have evolved from any other presently existing species. Rather than having evolved from chimps, humans share a close common ancestry with them. Therefore, rather than a grandfather to grandson association of chimpanzees to humans, we are more like cousins. No existing primate species is an ancestor of the human species.

It should also be noted that the terms evolution and biological evolution are often used interchangeably with Darwinian evolution.

Consulted Experts:
The BioLogos Foundation is grateful for the assistance of Darrel Falk and Francis Collins in drafting this response.[5]

Notes

1. In general, the definition of a species is a group of individuals that are capable of interbreeding and producing fertile offspring. However, it is difficult to apply this definition to the earliest stages of microbial life on earth, since there appears to have been extensive horizontal gene transfer between different early organisms.
2. University of California Museum of Paleontology, "Discrete Genes Are Inherited: Gregor Mendel," Understanding Evolution, http://evolution.berkeley.edu/evolibrary/article/_0/history_13.
3. For a more detailed response to these claims, see Francis S. Collins, *The Language of God: A Scientist Presents Evidence for Belief* (New York: Free Press, 2006), 132. See also Darrel R. Falk, *Coming to Peace with Science: Bridging the Worlds between Faith and Biology* (Downers Grove, IL: InterVarsity Press, 2004), 130.
4. Falk, *Coming to Peace with Science: Bridging the Worlds Between Faith and Biology*, 131.
5. All of Dr. Francis Collins' work on this response was completed before being sworn in as

Director of the National Institutes of Health.

Further Reading

Web sites

- The American Scientific Affiliation. “Creation and Evolution.”
- The Natural History Museum Board of Trustees. “What is Evolution?”
- University of California, Museum of Paleontology. "Understanding Evolution."

Articles

- University of California Museum of Paleontology. “Discrete Genes Are Inherited: Gregor Mendel.”

Books

- Alexander, Denis. *Creation or Evolution: Do We Have to Choose?* Oxford: Monarch Books, 2008.
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1994.