

## Misconceptions about Evolution and the Mechanisms of Evolution

Unfortunately, people have misconceptions about evolution. Some are simple misunderstandings; ideas that develop in the course of learning about evolution, possibly from school experiences and/or from the media. Other misconceptions may stem from purposeful attempts to interfere with the teaching of evolution.

As teachers, it is our role to treat all student questions with respect and initially to accept each question as the reflection of a legitimate desire to learn. However, some questions may well be designed to disrupt the learning process. We need to deal with intentionally disruptive questions in ways that are a bit different from legitimate inquiry. And it is important that we learn to distinguish between the two.

### Evolution and How it Works

Misconceptions about the history of life and how it came about are unfortunately very common. Most of these misunderstandings have to do with assumptions that evolution proceeds in a particular direction or that individual living things can choose to adapt. Here we examine five common misunderstandings about evolution and how it works.

#### Misconception: "Evolution is a theory about the origin of life."

Response: Evolutionary theory deals mainly with how life changed after its origin. Science does try to investigate how life started (e.g., whether or not it happened near a deep-sea vent, which organic molecules came first, etc.), but these considerations are not the central focus of evolutionary theory. Regardless of how life started, afterwards it branched and diversified, and most studies of evolution are focused on those processes.

#### Misconception: "Evolution is like a climb up a ladder of progress; organisms are always getting better."

Response: It is true that natural selection weeds out individuals that are unfit in a particular situation, but for evolution, "good enough" is good enough. No organism has to be perfect. For example, many taxa (like some mosses, protists, fungi, sharks, opossums, and crayfish) have changed little over great expanses of time. They are not marching up a ladder of progress. Rather, they are fit enough to survive and reproduce, and that is all that is necessary to ensure their existence.



wrong



right

Other taxa may have changed and diversified a great deal—but that doesn't mean they got "better." After all, climates change, rivers shift course, new competitors invade—and what was "better" a million years ago, may not be "better" today. What works "better" in one location might not work so well in another. Fitness is linked to environment, not to progress.

## Misconception: "Evolution means that life changed 'by chance.' "

Response: Chance is certainly a factor in evolution, but there are also non-random evolutionary mechanisms. Random mutation is the ultimate source of genetic variation, however natural selection, the process by which some variants survive and others do not, is not random.

For example, some aquatic animals are more likely to survive and reproduce if they can move quickly through water. Speed helps them to capture prey and escape danger. Animals such as sharks, tuna, dolphins and ichthyosaurs have evolved streamlined body shapes that allow them to swim fast. As they evolved, individuals with more streamlined bodies were more likely to survive and reproduce. Individuals that survive and reproduce better in their environment will have more offspring (displaying the same traits) in the next generation. That's non-random selection. To say that evolution happens "by chance" ignores half of the picture.



Tuna photo courtesy of the NOAA/Dept. of Commerce

The streamlined shape of these yellowfin tuna is no accident. A more streamlined shape allows these fish to move through the water faster. During their evolution, natural selection favored the more streamlined tuna.

## Misconception: "Natural selection involves organisms 'trying' to adapt."



*Adaptation doesn't involve trying.*

Response: Natural selection leads to adaptation, but the process doesn't involve "trying." Natural selection involves genetic variation and selection among variants present in a population. Either an individual has genes that are good enough to survive and reproduce, or it does not—but it can't get the right genes by "trying."

## Misconception: "Natural selection gives organisms what they 'need.' "

Response: Natural selection has no intentions or senses; it cannot sense what a species "needs." If a population happens to have the genetic variation that allows some individuals to survive a particular challenge better than others, then those individuals will have more offspring in the next generation, and the population will evolve. If that genetic variation is not in the population, the population may still survive (but not evolve much) or it may die out. But it will not be granted what it "needs" by natural selection.



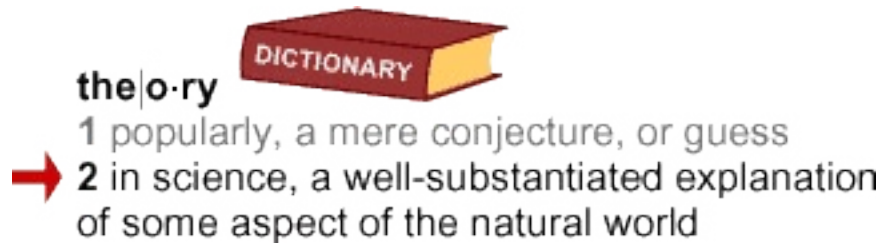
*Natural selection does not grant organisms what they "need".*

## Evidence Regarding Evolution

Many of the misconceptions about the evidence supporting evolution have been planted in the minds of the public through antievolution propaganda. The following notions may appear compelling at first glance, but are easily debunked with a little information.

## Misconception: "Evolution is 'just' a theory."

Response: Scientific theories are explanations that are based on lines of evidence, enable valid predictions, and have been tested in many ways. In contrast, there is also a popular definition of theory—a "guess" or "hunch." These conflicting definitions often cause unnecessary confusion about evolution.



## Misconception: "Evolution is a theory in crisis and is collapsing as scientists lose confidence in it."

Response: Scientists do not debate whether evolution (descent with modification) took place, but they do argue about how it took place. Details of the processes and mechanisms are vigorously debated. Antievolutionists may hear the debates about how evolution occurs and misinterpret them as debates about whether evolution occurs. Evolution is sound science and is treated accordingly by scientists and scholars worldwide.

**Misconception: “Gaps in the fossil record disprove evolution.”**

Response: The fact that some transitional fossils are not preserved does not disprove evolution. Evolutionary biologists do not expect that all transitional forms will be found and realize that many species leave no fossils at all. Lots of organisms don’t fossilize well and the environmental conditions for forming good fossils are not that common. So, science actually predicts that for many evolutionary changes there will be gaps in the record.

Also, scientists have found many transitional fossils. For example, there are fossils of transitional organisms between modern birds and their theropod dinosaur ancestors, and between whales and their terrestrial mammal ancestors.

**Misconception: “Evolutionary theory is incomplete and is currently unable to give a total explanation of life.”**

Response: Evolutionary science is a work in progress. New discoveries are made and explanations adjusted when necessary. And in this respect, evolution is just like all other sciences. Research continues to add to our knowledge. While we don’t know everything about evolution (or any other scientific discipline, for that matter), we do know a great deal about the history of life, the pattern of lineage-splitting through time, and the mechanisms that have caused these changes. And more will be learned in the future. To date, evolution is the only well-supported explanation for life’s diversity.



**Misconception: “The theory of evolution is flawed, but scientists won’t admit it.”**

Response: Scientists have examined the supposed “flaws” that creationists claim exist in evolutionary theory and have found no support for these claims. These “flaws” are based on misunderstandings of evolutionary theory or misrepresentations of evidence. Scientists continue to refine the theory of evolution, but that doesn’t mean it is “flawed.” Science is a very competitive endeavor and if “flaws” were discovered, scientists would be more than glad to point them out.

## Misconception: “Evolution is not science because it is not observable or testable.”

Response: Evolution is observable and testable. The misconception here is that science is limited to controlled experiments that are conducted in laboratories by people in white lab coats. Actually, much of science is accomplished by gathering evidence from the real world and inferring how things work. Astronomers cannot hold stars in their hands and geologists cannot go back in time, but in both cases scientists can learn a great deal by using multiple lines of evidence to make valid and useful inferences about their objects of study. The same is true of the study of the evolutionary history of life on Earth, and as a matter of fact, many mechanisms of evolution are studied through direct experimentation as in more familiar sciences.



Fossils such as *Archaeopteryx* give us snapshots of organisms as they adapt and change over time.



Studying modern organisms such as elephant seals can reveal specific examples of evolutionary history and bolster concepts of evolution.



Artificial selection among guppies can demonstrate microevolution in the laboratory.



Laboratory experimentation with fruit flies demonstrates the power of genetic mutation.

Photo credits:

*Archaeopteryx* and elephant seal photos courtesy of Dave Smith, UCMP

Guppy photos courtesy of Cara Gibson and Katie McGhee

Fruit fly image courtesy of Jean-Michel Muratet, Syndicat National des Ophthalmologistes de France (SNOF)

**Misconception: “Most biologists have rejected ‘Darwinism’ (i.e., no longer really agree with the ideas put forth by Darwin and Wallace).”**

Response: Darwin’s idea that evolution generally proceeds at a slow, deliberate pace has been modified to include the idea that evolution can proceed at a relatively rapid pace under some circumstances. In this sense, “Darwinism” is continually being modified. Modification of theories to make them more representative of how things work is the role of scientists and of science itself.

Thus far, however, there have been no credible challenges to the basic Darwinian principles that evolution proceeds primarily by the mechanism of natural selection acting upon variation in populations and that different species share common ancestors. Scientists have not rejected Darwin’s natural selection, but have improved and expanded it as more information has become available. For example, we now know (although Darwin did not) that genetic mutations are the source of variation acted on by natural selection, but we haven’t rejected Darwin’s idea of natural selection—we’ve just added to it.



## **Evolution and Religion**

The alleged incompatibility of religion and evolution has been used as a way of persuading people to deny the history of the Earth. The following misconception is dependent on a misunderstanding of the functions of both science and religion.

**Misconception: “Evolution and religion are incompatible.”**

Response: Religion and science (evolution) are very different things. In science, only natural causes are used to explain natural phenomena, while religion deals with beliefs that are beyond the natural world.

The misconception that one always has to choose between science and religion is incorrect. Of course, some religious beliefs explicitly contradict science (e.g., the belief that the world and all life on it was created in six literal days); however, most religious groups have no conflict with the theory of evolution or other scientific findings. In fact, many religious people, including theologians, feel that a deeper understanding of nature actually enriches their faith. Moreover, in the scientific community there are thousands of scientists who are devoutly religious and also accept evolution.