III. Short FAQs

❖ How long does it take for evolution to happen?

It depends on which organism is evolving and what kind of evolution you are interested in. Here are a few examples:

- Shift in gene frequency in bacterial populations (e.g., evolution into a largely antibiotic resistant strain): hours or days
- Shift in gene frequency in human populations (e.g., evolution favoring genes that let individuals digest milk): hundreds or thousands of years
- Early stages of speciation in flies: 200 years
- Evolutionary transition from fish ancestors to walking vertebrates: tens of millions of years

❖ How did life start?

Three and a half billion years ago, life originated in a series of small steps, each building upon the complexity that evolved previously. First, simple organic molecules formed, possibly near an oceanic hydrothermal vent or a hot spring. Then, molecules that could copy themselves evolved and began to undergo natural selection. Eventually those replicating molecules became enclosed within a cell membrane and evolved into organisms we would recognize as alive. Science can help us reconstruct the steps and natural processes through which life evolved.

❖ How do we get new species?

Though there many ways that new species can arise, biologists think that the following process is common: a population is split into two sub-populations by some geographic barrier, the two sub-populations evolve in isolation, and eventually the sub-populations evolve so many differences that—even if they were reunited—they would not or could not successfully mate with one another. At this point, speciation has occurred: a single ancestral species has evolved into two separate daughter species.

❖ Where does new variation come from?

The ultimate source of genetic variation is random mutation. Mutations are "random" in the sense that the sort of mutation that occurs cannot generally be predicted based upon the needs of the organism. So, for example, in the exhibit, the gene variants that caused some baby dinosaurs to have fuzz originally arose through the process of random mutation. However, once the gene variant was present in the population, it spread through the nonrandom process of natural selection. The offspring of two parents are all slightly different from one another because they each got slightly different combinations of gene versions from their parents—but the ultimate source of those gene versions is random mutation.

❖ What's the difference between microevolution and macroevolution?

Microevolution is what biologists call evolutionary change that occurs within a single population or species (e.g., an increase in the frequency of dinosaurs with tiny feathers from one generation to the next). Macroevolution is what biologists call evolutionary change that occurs on a scale that transcends the boundaries of a single species (e.g., the evolution and radiation of the dinosaur lineage into many different species of non-avian dinosaurs and birds). Despite their differences, evolution at both of these levels relies on the same, established mechanisms of evolutionary change: mutation, migration, *genetic drift*, and natural selection.

genetic drift—random changes in the gene frequencies of a population from generation to generation. This happens as a result of sampling error—some individuals just happen to reproduce more than others, not because they are "better," but just because they got lucky. This process causes gene frequencies in a population to drift around over time. Some genes may even "drift out" of a population (i.e., just by chance, some gene may reach a frequency of zero). In general, genetic drift has the effect of decreasing genetic variation within a population.

❖ Who came up with the idea of evolution?

Charles Darwin championed the idea that species evolved from common ancestors, and he and Alfred Russel Wallace came up with the idea of natural selection as a mechanism of evolution, but other evolutionary ideas were around long before Darwin and Wallace. For example, in the 1700s, Georges-Louis Leclerc Buffon argued that life was extremely old and had changed over time, and in the early 1800s, Jean Baptiste Lamarck proposed several ideas about the mechanisms through which life might evolve.

❖ Do scientists still think that Darwin was right?

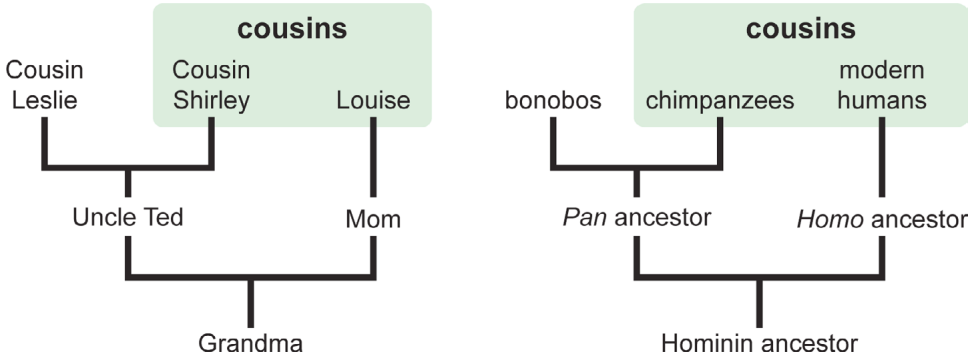
Many lines of evidence and decades of research support Darwin's central ideas—that evolution occurs through natural selection and that different species share common ancestors. In fact, Darwin's writing anticipated many of the key components of modern evolutionary theory. However, scientists now think that Darwin was wrong about some things (e.g., his ideas about the mechanism of inheritance). And, of course, Darwin didn't anticipate *all* parts of modern evolutionary theory (e.g., genetic drift). As scientists find new lines of evidence and new ways of explaining that evidence, their ideas about the how the world works change. This is a normal part of science—so the fact that scientists now reject some aspects of Darwin's thinking about evolution is not surprising and reflects normal scientific progress.

❖ What happened to the dinosaurs?

Some dinosaurs evolved into birds and remain alive today. However, many dinosaur lineages—along with tons of other sorts of organisms—went extinct about 65 million years ago at the end of the Cretaceous period. Their extinction was probably related to a massive asteroid that struck Earth and that may have thrown up a sun-blotting cloud of dust and ignited wildfires and/or oil deposits. Around the same time, the earth was also experiencing climate change and significant volcanic activity that may have further contributed to the extinctions.

❖ Did humans evolve from chimpanzees?

No. Humans did not evolve from chimpanzees. Humans and chimps are both modern organisms. Our relationship is more like that of cousins than that of children to their parents. We share a recent common ancestor with one another. That ancestor was neither chimp nor human—but it was an ape. This means that, technically, humans are considered to *be* apes—just as we are considered to be primates, mammals, vertebrates, and animals.



❖ Are humans still evolving?

Since evolution is simply changes in gene frequency in a population from one generation to the next, the answer to this question is almost certainly "yes." At the very least, the frequencies of different gene versions change a small amount each generation due to genetic drift. However, more significant evolutionary change may be occurring as well. For example, genes for resistance to HIV may be spreading in some populations, and other genes correlated with producing fewer offspring may be decreasing in frequency. Though this is an area of active research, one thing is for certain: modern humans have changed the ways that natural selection can act on us. Our ability to mediate our environments with technology—to keep ourselves warm, to treat

diabetes with insulin, and to provide food for those without farming, hunting, or gathering skills, amongst a myriad of other cultural innovations—has changed our evolutionary landscape. So, for example, because of the availability of insulin in many developed countries, the gene versions that contribute to juvenile diabetes are no longer strongly selected against. But this sort of technological innovation doesn't necessarily mean that we've stopped evolving. It may just be indicative of the changing rules of the evolutionary game that we humans are playing today.

❖ Is evolution against religion?

The idea 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 were 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.

❖ Why doesn't this exhibit discuss God's role in evolution or creationism?

Religion and science 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. Creationism deals with supernatural explanations and so is not a part of science. Because this is a science exhibit in a science museum, it is only appropriate to address scientific explanations. This exhibit is not a denouncement of religion; in fact, many people have no problem at all reconciling acceptance of evolution with religious faith and find that an understanding of science enriches their appreciation of the natural world.