Teacher Tune-up

Quick Content Refresher for Busy Professionals

What are some common misconceptions related to evolution?

Evolution is about progress or advancement. No, evolution is about change, not advancement up a hierarchy. One concise definition of evolution is **descent with modification**. Time passes and changes appear over generations of organisms. We can observe these changes in small-scale or microevolution (like the changing abundance of light- and dark-colored peppered moths in nineteenth and twentieth century England, as changes in industrial pollution altered what colors worked best as camouflage), or in large-scale or macroevolution, in which entirely different species descend from a common ancestor. None of this change means that organisms are getting better and better on some absolute scale.

Evolution is purposeful. No, evolution results from the interaction of several key mechanisms—mutation, migration, genetic drift, and natural selection—without regard to intention or purpose. **Mutation** introduces random genetic novelty. **Migration** of individuals into or out of a population adds to or subtracts from the gene pool of that population. **Genetic drift** is the slight change in frequency of genes from generation to generation due to random events, rather than to the fitness of organisms (even a bug with all the genetic advantages that would seem to promise a bright evolutionary future can be squashed by a random falling rock). These mechanisms contribute to genetic variation among the members of a population (and, where relevant, genetic reshuffling by sexual reproduction causes additional genetic variation). In the long run, **natural selection** shapes organisms over generations wherever there is (1) genetic variation, (2) differential reproduction (some individuals inevitably produce more surviving offspring than others in this hard world), and (3) heredity.

Organisms do not evolve on purpose, and natural selection does not act upon organisms purposefully. That's what makes it different from the artificial selection people use to breed plants and animals with desired traits.

Okay, if evolution isn't purposeful, it's completely random. No, it doesn't have to be one or the other. Natural selection is quite strict in its action upon different characteristics (organisms' structures, processes, and behaviors), and so, indirectly, on the genes that code for those characteristics. Mutation, migration, and genetic drift pitch various genetic options, and in the context of the available niches in an environment, natural selection is anything but random in its verdict about what flies and what fails.

Evolution is all about "survival of the fittest." Yes and no. It depends what you mean by "fittest." Oh yeah, and also what you mean by "survival." In the context of evolutionary theory, fitness doesn't simply mean being bigger, stronger, and faster. It's not the kind of fitness you might strive for at the gym. Rather, evolutionary fitness is relative: it's about fitting into whichever niche an organism occupies, so that the organism's genetic makeup can be passed on to more offspring.

And while that means that evolution is about the survival of genes from one generation to the next, it doesn't necessarily mean that individual organisms

need to survive a long time to be evolutionarily successful. In some species of spiders, small males submit to sexual cannibalism as the price for getting to breed with larger (apparently hungry and unsentimental) females. In many other animal species, non-breeding individuals serve their packs or hives in ways that improve the odds that their kin (with closely related DNA) will survive. In short, many genes have ways of reproducing themselves besides building big, strong, fast individuals that survive a long time, breed like crazy, and just look out for number one.

Organisms mutate in order to adapt and improve. No, mutation is a random process. In superhero fiction, mutation may come across as a way for people (and teenage turtles) to quickly gain marvelous attributes and abilities. But in reality, mutation is not purposeful, and is usually either harmless or downright disadvantageous. What's more, only mutations in reproductive cells—sperm and eggs—can introduce novel genetic variations for natural selection to play upon. Mutations in the DNA of somatic cells (non-reproductive cells) aren't inherited by offspring.

Individual organisms can adapt through effort, and then their offspring can inherit those adaptations. One of the earliest theorists of evolution, Jean-Baptiste Lamarck, put forth this erroneous notion in 1801. He believed that when an organism used certain body parts, those parts become stronger and larger, and that these changes were then passed on to later generations. Unused parts would diminish in the parent and be correspondingly diminished in the offspring from the start. A classic example of Lamarckian evolution is the notion that giraffes evolved their long necks because individuals strained to reach higher leaves until their necks actually grew longer, and they passed these longer necks on to their offspring. Many generations of this, the Lamarckian story goes, produced today's spectacularly long-necked giraffes.

Though Lamarck was ahead of his time in perceiving that organisms had evolved over time, the details of his evolutionary theory turn out not to fit most of the evidence. A person who builds up his or her muscles by exercise does not necessarily have more muscular children. If you dock a puppy's tail, its offspring will not be tailless. If you bonsai a tree, its offspring will not be smaller.

To be fair, we should note that recent research into epigenetics has reintroduced a kind of Lamarckian effect. Epigenetics is the study of how changes in genetic expression can be passed on to new generations without actually changing the genes themselves. The set of genes that makes up an organism's genome is like an instruction manual, but not all of the pages of the manual are being read at all times. Chemical bookmarks tag different parts of the genome for expression or suppression (which is how your muscle cells, skin cells, and neurons are able to have different forms and do different jobs even though they have identical DNA). Scientists are now discovering that some epigenetic tags can pass between generations, so that a parent's life experience can have some influence on a child's gene expression. This aspect of inheritance is relatively limited, however. It does not change genes, and cannot lead to the evolution of new species.

Charles Darwin introduced a more sophisticated theory of evolution with his publication of *On the Origin of Species by Means of Natural Selection* in 1859. Time and evidence have borne out the Darwinian view. Darwin understood the idea of inheritable traits that do not change in an individual's lifetime. An individual organism is basically genetically immutable; it must take its chances in life with the genes it started with. Only over generations does natural selection reshape species by acting on genetic variation (brought on by mutation, migration, and genetic drift).