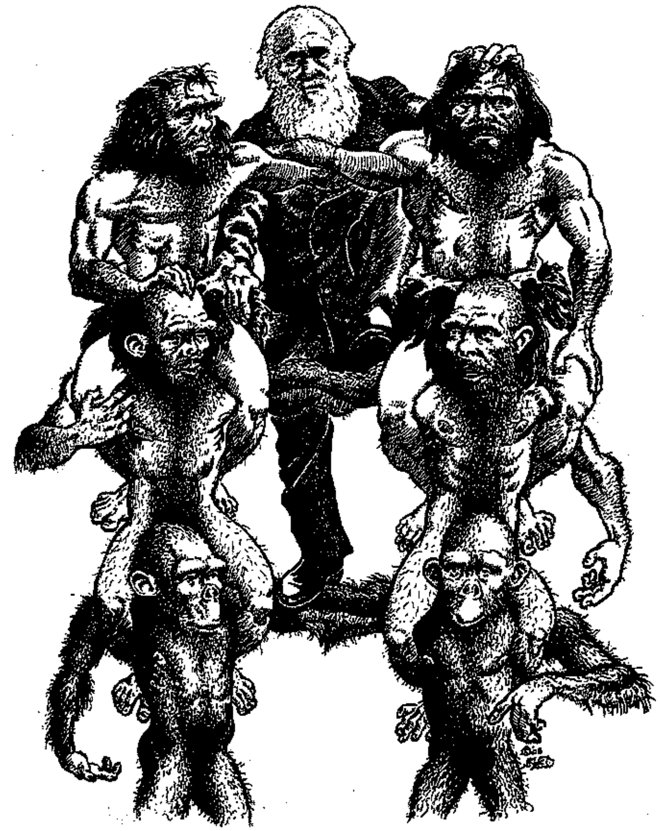

Myth Three

The Ladder of Progress

In 1579 the Franciscan missionary Didacus Valades penned a metaphorical drawing of the ordered levels of all living things from the lowliest life-forms—which he placed at the bottom of his drawing—to the highest life-forms at the top. His drawing shows these levels connected together by a ladderlike chain. Today, many people believe that evolution is similar to Valades' drawing, involving a ladderlike progression, as though nature had a built-in aim to strive ever "upward," rung after rung, from simple to more complex organisms, finally culminating in humans—the ultimate goal of evolution—perched triumphantly at the top rung of the ladder. It's thought that this striving in the direction of perfection (meaning humans, of course) is part of the natural process of evolution.

This idea of evolution or any natural process having an ultimate goal or a purpose is known as *teleology*. But scientists, for all their searching, haven't discovered any evidence of teleology in evolution. There appears to be no inherent drive that propels the evolution of species "upward" toward the ultimate goal of humans, or of any other species. But this idea of higher and lower levels of life has a long history, and perhaps a look at that history will explain why this image is still with us today.

The Great Chain of Being

All human societies have ways of classifying things and putting them into categories that bring order to the world. During the medieval and Renaissance periods, Europe was no different; there was a grand classification system that was biological, geological, and theological, all in one. This system was known as the Great Chain of Being, or the *Scala Natura* (Nature's Ladder), and it was designed to inventory and categorize everything that existed in the known universe in an orderly way.[1] Like Valades' drawing, it was structured in a ladderlike hierarchy placing the least perfect things at the bottom of the chain (or ladder) to the most perfect at the top. In its simplest form the Great Chain of Being consisted of rocks and minerals at the bottom, followed by plants, then animals, then humans, then angels, and finally God.[2] This gradation of nature, from the least perfect thing on up, was thought to be how God created everything in the universe in an orderly and hierarchical way.

Each of these categories of the chain below God was divided into many smaller sections in order to fit every known being and thing into its proper place. Arthur O. Lovejoy's historical account of the Great Chain of Being reveals its cultural influence:

> The result was the conception of the plan and structure of the world which, through the Middle Ages and down to the late eighteenth century, many philosophers, most men of science, and, indeed, most educated men, were to accept without question—the conception of the universe as a 'Great Chain of Being,' composed of an immense . . . number of links ranging in hierarchical order from the meagerest kind of existents . . . through 'every possible' grade up to the *ens perfectissimum* [most perfect being, i.e., God].[3]

Generally, within the lowest link, rocks of no value to humans were at the bottom, fertile soil was higher up, and various gems and metals found in the earth were even higher, with gold (or diamonds) at the top. Within the plant category, the higher ranking usually went to plants beneficial to humans, such as fruit trees, or to those considered beautiful, such as roses; weeds and poisonous plants were at the bottom. In the animal category, those deemed more noble or intelligent were usually ranked higher than pests or dangerous animals. The human category ranked people according to their social station in life, with kings and popes high above lowly peasants.[4] Even among angels, the archangels ranked higher than ordinary angels.

This Great Chain of Being scheme, however, was not about evolution, an idea that didn't exist in any intelligible form until the late 1700s. There was no notion at this time of new species evolving from older species, or of all species being related and sharing a common ancestor, because all living things were seen as *fixed*, in that they were all created by God during the time of creation and in the same form then that they have now. The Great Chain of Being simply ranked everything in its proper place, in an orderly and rational manner, according to God's original plan. It's no surprise that humans and what humans valued fared quite well in the rankings.

Some later thinkers, such as Lamarck, tried to integrate the Great Chain of Being with the idea of species changing over time. Lamarck thought (correctly) that new species could evolve from older species by natural means, but he believed that evolution moved in a straight, upward direction toward perfection along something resembling the ladder of the Great Chain of Being, with humans at the top, of course. Thus, he thought that humans should be the ultimate benchmark by which all animals are judged, writing:

> It is clear that since the organization of man is the most perfect, it should be regarded as the standard for judging of the perfection or degradation of the other animal organisations.[5]

The Great Chain of Being scheme was so pervasive during Lamarck's time that it made sense to try to link it up with evolution. In a way it wasn't a bad idea considering how little was known about the workings of evolution. And to this day the idea of a natural, goal-directed striving up the ladder, or the chain, in the direction of humans makes for a compelling image that's at the root of many of our misunderstandings about evolution. This image, however, is incompatible with how we now know evolution works, precisely because it's teleological. Not only has no mechanism been found that directs evolution "upward" in a straight line, but also frequent extinctions, and unpredictable changes in the direction in which so many organisms have evolved, show otherwise.

New and Improved?

If we view evolution as striving upward, it's easy to think that more recent species will be "more evolved" or better adapted to their environments than species with longer histories. Surely we can say that newer species are more fit than older species, and that this is progress. Or is it? It would be a mistake to *assume* that a newer species is better

adapted or more fit than an older species just because it's newer. If Earth was hit by a large asteroid, similar to the one that appears to have wiped out the dinosaurs (plus half of all living species) sixty-five million years ago, then just about any living thing would be hard put to survive. That asteroid, which slammed into the earth near the Yucatan Peninsula in Mexico, is estimated to have been ten billion times more powerful than the atomic bomb dropped on Hiroshima.[6] No animal, no matter how new it is, has evolved a thick enough skin or shell to protect it from that kind of devastation. Some fortunate animals might be safe from the firestorms that would quickly engulf the earth after an asteroid impact if they were far enough away, in a naturally protected area. But if firestorms aren't enough to cope with, a massive asteroid smashing into the earth would kick up so much dust and debris that it could block out the sun for months. Before long, plants would die from lack of sunlight, then animals that feed on plants would die, then animals that feed on animals would die. Yet, if a particular species of animal was small enough, could eat most anything, and existed in large enough numbers, then some of them just might be lucky enough to survive the ensuing "nuclear winter" if they could find enough rotting plant and animal matter to feed on.

If such an asteroid were to hit Earth now, older creatures, such as cockroaches and rats, might stand a better chance of avoiding extinction than more recent arrivals, such as humans. While some newer species may have advantages over older species in particular environments, in the face of a massive catastrophe all bets are off. Being a newer species, then, isn't enough to ensure survival.

Catastrophes such as asteroids aside, what ultimately matters is how well adapted the members of a species are to their selective environments. If those environments alter in significant ways, such as in temperature, weather or climate changes, the availability of food and water, the introduction of new predators, and so on, we can't assume that a more recent species will be better adapted than an older species to the new environmental conditions.

The terms *higher* and *lower* add more confusion to our understanding of evolution. These terms simply mark the arrival of a species on the historical tree of life, known as the *phylogenetic tree*. A species that arose further back in time is lower, and one that arose more recently is higher. But these designations don't mean that a species is more or less adapted to its environment.

Chinese giant pandas are higher on the phylogenetic tree than Nile crocodiles, in that their species is a more recent arrival.[7] But a good case could be made that Nile crocodiles are better adapted to their environment because they'll devour just about any animal they can sink their teeth into. Giant pandas, on the other hand, have evolved a very specialized diet, relying almost entirely on bamboo. Depending on only one food source, as giant pandas do, is a risky way to make a living. If the bamboo that the pandas rely on was wiped out by disease or by any other cause, it could spell their demise, whereas Nile crocodiles—having a more varied diet—may well survive if a number of their food sources disappeared. So, the fact that giant pandas are higher on the phylogenetic tree than Nile crocodiles doesn't mean they're better equipped to survive. It just means they're more recent.

Complexity

Just as the words *higher* and *lower* can be misleading, so can the notion of complexity. Living things today are, on average, more complex than their ancestors of billions of years past. Some of the earliest life-forms were simple bacteria, and if they were to undergo any changes or adaptations, there'd be no place to go but in the direction of complexity, since you can't get much simpler than bacteria.[8] It's obvious that natural selection has helped shape the complex evolutionary changes through the generations, from single-celled organisms to simple plants and animals, leading to fish, reptiles, amphibians, birds, and eventually mammals. So doesn't this show that progressive complexity is a necessary part of the evolutionary process for all living things? The answer is no.

Bacteria are simple organisms, and many have not changed much for billions of years. Indeed, they may be the most successful group of organisms on the planet, having an estimated total biomass (weight) greater than all other living things combined.[9] Crocodiles haven't changed much either from their days living among the dinosaurs over two hundred million years ago. The rather prehistoric-looking Coelacanth fish, which first appeared around three hundred and fifty million years ago, was thought to have gone extinct sixty-five million years ago. But one was caught alive in 1938 off the southeast coast of Africa, and since then over two hundred have been discovered. These "living fossils" don't appear to have changed much when compared with the fossilized remains of their ancient ancestors.

It would be a mistake, then, to assume as a general rule that complexity is a universal trend in evolution, or that it always confers an advantage for survival. What matters is how well organisms are adapted to their environment, and how well they can adapt to frequent changes in that environment. If evolutionary changes toward complexity provide an advantage for those who acquire them, then those changes will be selected for. If not, they won't. Interestingly, some species lines have become less complex over time, such as cave-dwelling fish that no longer have functioning eyes, and some internal parasites that have lost all means of self-locomotion.[10] Moreover, the skulls of birds and mammals have become simpler than those of their early fish ancestors.[11]

Progress in Evolution

So how exactly does the idea of progress apply to evolution? Evolutionary adaptations can build on themselves in a cumulative way, and these adaptations can help improve the way of life for a particular population of organism. These gradual, beneficial changes in lineages can be seen as evolutionary progress.[12] In "Myth Two: It's Just a Theory," we saw how wild boars can develop a slightly sharper sense of smell, allowing them to better sniff out and to escape more readily from Komodo dragons. It was also pointed out that Komodo dragons can evolve advantages themselves, such as becoming faster or acquiring finer hearing, making them better at preying on boars. This continually evolving relationship between predator and prey species is known as an *evolutionary arms race*.[13]

Within this arms race, spanning hundreds or thousands of generations, both the prey and the predator can evolve in a progressive sense. If the wild boars evolve a slightly sharper sense of smell with which they can elude Komodo dragons successfully, then the boars will have an edge in the arms race. If no beneficial variations arise in the Komodo dragons that could help them counter this edge, then the population of Komodo dragons may die of starvation, depending on the availability of other prey species. But a beneficial variation, such as slightly larger leg muscles or better hearing, may arise and be passed down through the generations, eventually spreading throughout the Komodo dragon population precisely because it confers an advantage. Then the Komodo dragons will have the upper hand in the arms race. If the population of boars can't counter this advantage with another beneficial variation of their own, they might all be eaten eventually, and the arms race will come to an end.

But many arms races have continued for some time, with prey getting better at escaping predators, and subsequently, predators getting better at capturing prey, and round and round. There's a kind of ongoing feedback loop between the two species. Those that can't compete in the arms race either starve or get eaten.[14] Those that survive tend to be the ones better adapted to the changing conditions. The kinds of cumulative changes that provide evolutionary improvements in arms races are numerous. They can include improvements in ears, noses, eyes, muscles, teeth, claws, camouflage, communication signals, brain functions, and any other changes that can provide an edge in the arms race.

A spectacular example of an animal evolving variations under pressure to avoid predation is the octopus. Its ability to change its skin color and texture within a second to almost perfectly match its surroundings is so amazing that it seems like a high-tech Hollywood special effect, and it certainly makes the chameleon look like a novice.

So, over hundreds or thousands of generations, Komodo dragons and wild boars (and other animals in predator/prey struggles) may evolve progressive adaptations, precisely because of the arms race between them. Over time, the Komodo dragons and the boars will become much better at hunting and fleeing, respectively, than their ancestors were.[15] If you could travel back in time and return with a wild boar from thousands of generations ago, that boar wouldn't stand a chance against a modern Komodo dragon because the modern Komodo dragon has progressed from the dragons that the boar would be used to.[16] The same goes for transporting an ancestor of the Komodo dragons into the present. They would be hard put to catch any modern boars because the modern boars have also progressed.

Curiously, as this arms race develops, the modern populations of boars are really no better at eluding modern populations of Komodo dragons than their ancestors were in their arms race. Likewise, the modern Komodo dragons are no better at catching modern boars than their ancestors were. Since the dragons and boars are coevolving within this arms race, they're still pretty much evenly matched, despite their being better at escaping or at hunting, respectively, than their ancestors were.

This pattern of evolutionary improvement occurring while still being evenly matched with one's "enemy" is known as the *Red Queen Effect*.[17] This is a reference to a scene in Lewis Carroll's *Through the Looking Glass*, where Alice and the Red Queen are running hand in hand as fast as they can, yet getting nowhere. The trees and other scenery around them haven't changed at all. Feeling confused, Alice says, "Well, in *our* country you'd generally get to somewhere else—if you ran very fast for a long time as we've been doing." "A slow sort of country!" says the queen. "Now, *here*, you see, it takes all the running *you* can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

So, we can talk about progress in terms of the evolutionary adaptations that build on themselves in a cumulative way, where these adaptations help improve the way of life of members of a species engaged in a predator/prey arms race. This progress isn't measured by how successful the predators or the prey are in their arms race—which doesn't vary much—but by the changes in the equipment for success, such as a keener sense of smell or faster legs, possessed by participants in the arms race.[18] Progressive arms races aren't limited to predator/prey relationships either. They can also exist between parasites and their hosts, and between plants and herbivores.[19]

We can also view progress "purely empirically as the achievement of something that is somehow better, more efficient, and more successful than what preceded it."[20] Natural selection generally favors those individuals better adapted to their environment and usually eliminates those who aren't as well adapted. So, those who survive in a particular lineage are on average better adapted than those who don't survive. Evolution in this sense is definitely progressive.[21]

Throughout the long history of evolution various innovations (or transitions) have arisen, enhancing the adaptability of those organisms that possess them.[22] Such innovations include the origin of chromosomes (parts of a cell that contain genetic instructions), eukaryotes (cells with a clearly defined nucleus), multicellularity, sexual reproduction, specialized organs and structures such as the eye, endothermy (warm-bloodedness), parental care of the young, large central nervous systems, and even language and culture. The organisms in which these progressive innovations first began to appear were quite successful, and this contributed to the spread of their ecological influence.[23] The fact that many of these innovations are shared by large numbers of species attests to their being successful evolutionary improvements.

But these improvements were not inevitable. They didn't have to happen. And these progressive changes were not part of some built-in aim of evolution, nor are they predictable.[24] Furthermore, these evolutionary transitions may not be permanently advantageous over

extremely long periods of time, such as a billion years, because it's probable that major environmental catastrophes (such as space debris impacts) will occur over this long time scale, causing extinction no matter how well adapted species are. Similarly, the progressive changes in arms races between specific predator and prey species may last millions of years, but they're unlikely to last hundreds of millions of years.[25] So, progress makes the most sense when talking about gradual changes within a particular evolutionary line during a long, but limited, time period, *not* over the entire history of evolution or the evolution of *all* living things. This becomes obvious when we realize that about 99.99 percent of all evolutionary lines that have ever existed are now extinct, many of which (such as dinosaurs) had surely evolved progressive improvements in their equipment for survival.

The Measure of Man

We must avoid the temptation to measure all forms of progress in terms of changes that have been improvements in the evolution of humans. Bigger brains, bipedality, opposable thumbs, extended care of the young, and development of language and culture are all features that have been progressive adaptations in the human line. But when we measure progress in other species, we must use criteria that apply to them, not necessarily to us, although we may share some of the same adaptations.

It may help us reduce our human bias if we view various evolutionary changes as progressive when they offer improvements from an engineering perspective in the equipment for survival.[26] Not that engineers couldn't conceive of better "designs," but that they could clearly recognize improvements in efficiency in the same way they could recognize analogous improvements in the transition from the first flying machine of the Wright brothers to the modern jet. New "variations" have been added over time to flying machines that make them faster, safer, and more efficient. And many "variations" have been eliminated, in a manner analogous to natural selection, if they do just the opposite.

Evolutionary changes such as a sharper sense of smell in wild boars; improved echolocation (radar) in bats; strength and dexterity of elephant trunks; bigger teeth and claws in lions; agile wings of swallows; plus various innovations shared by numerous species such as multicellularity, sexual reproduction, and specialized organs, are all examples of progress in terms *relevant to the ways of life of those animals that possess these improvements*. Ultimately, human evolution is not the yardstick by which to measure progressive adaptations in other species.

Humans do seem to be the most intelligent species on Earth, but this wasn't inevitable. Things could easily have turned out otherwise. If the chimplike ancestors of humans had not moved out of the forest and into the savanna, the whole course of human evolution might not have happened. If our early ancestors had been unable to adapt to their new environment, then chimpanzees might be the most intelligent animals on Earth without being much different than they are today.

There are plenty of "what ifs" in the history of the evolution of every species. If certain variations had not arisen, if selective pressures and environments were different, and if fewer or more natural catastrophes had occurred, Earth would surely be a very different place. And even though humans happen to be the most intelligent species on Earth, it was just a matter of chance, not part of a built-in goal of evolution.

The Big Picture

The image of a Ladder of Nature or Great Chain of Being suggests that evolution has a goal or an overall direction, often thought to be humans. But we know this isn't the case. There is no intent, or ultimate aim, in replication, variation, selection, nor any other mechanism of evolution. Although there have been progressive improvements in various evolutionary lines, and we do recognize the evolution of complexity over time, perhaps the image of a bush works

better as an analogy for the *big picture* of evolution. Unlike a ladder or a chain, a bush can branch off in many directions—up, down, left, right, and anywhere in between—and new branches can sprout off of older branches without implying that those farther from the trunk are more perfect or better adapted to their environments than those nearer to the trunk.

Notes

1. The Great Chain of Being idea has its roots in ancient Greece, in that its creators borrowed heavily from Aristotle's taxonomy (categorizing of living things) and Plato's idea of the Good. These borrowed ideas were altered to accommodate a Christian worldview. For an enlightening intellectual history of the Great Chain of Being idea, see A. O. Lovejoy, *The Great Chain of Being: A Study of the History of an Idea* (Cambridge, MA: Harvard University Press, 1936).

2. The lowest category of the Great Chain of Being was considered more inclusive than only rocks and minerals. Basically, anything that simply existed (but was not alive) was placed in this category, which also included celestial bodies, fire, and water. The plant category added life to simple existence. The animal category added mobility and passions to existence and life. And the human category included reason on top of existence, life, mobility, and passions.

3. Lovejoy, *The Great Chain of Being*, p. 59.

4. The Great Chain of Being scheme also explained morality as understood by the Christian views of the times. The lowliest forms (minerals, plants, and animals) were considered strictly physical, without spirit. The angels and God were seen as pure spirit. Humans fell somewhere in between, being both physical and spiritual. Individual human moral struggles were seen as battles between the material world through the temptations of the flesh (lust, greed, anger, jealousy, etc.), and the spiritual world through the pull of one's God-given conscience.

5. J. B. Lamarck, *Zoological Philosophy*, trans. H. Elliot (Chicago: University of Chicago Press, 1984), p. 73.

6. For more on the evidence supporting the asteroid impact theory of

dinosaur extinction, see W. Alvarez and F. Asaro, "An Extraterrestrial Impact (Accumulating Evidence Suggests an Asteroid or Comet Caused the Cretaceous Extinction)," *Scientific American* 263, no. 4 (October 1990): 78–84. See also R. Cowen, *History of Life*, 4th ed. (Malden, MA: Blackwell, 2005), chap. 16. The energy released from the asteroid is estimated to have been equivalent to one hundred million megatons of TNT. The Hiroshima bomb was 0.01 megatons.

7. It's estimated that pandas first appeared around fifteen million years ago, whereas crocodiles first appeared around two hundred and forty million years ago.

8. For a detailed explanation of how the simplest life-forms such as bacteria can't really get much simpler, and if they did change it would inevitably be in the direction of complexity, see S. J. Gould, *Full House: The Spread of Excellence from Plato to Darwin* (New York: Harmony Books, 1996), chap. 13. For a critique of Gould's position on the implications of this view as it applies to progress in evolution, see R. Dawkins, "Human Chauvinism," *Evolution* 51, no. 3 (1997): 1015–20.

9. E. Mayr, *What Evolution Is* (New York: Basic Books, 2001), p. 278. See also Gould, *Full House*, p. 194.

10. Dawkins, "Human Chauvinism," p. 1018; Gould, *Full House*, pp. 200–201.

11. Mayr, *What Evolution Is*, p. 214.

12. This definition of progress is a slight simplification of Dawkins's excellent definition of progress, which he defines as "a tendency for lineages to improve cumulatively their adaptive fit to their particular way of life, by increasing the numbers of features which combine together in adaptive complexes." See Dawkins, "Human Chauvinism," p. 1016. Evolutionary lineages (or lines) refer to the sequence of ancestral populations to descendent populations.

13. For a thoroughly convincing explanation of how predator/prey arms races can count as progress in evolution, see R. Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design* (New York: Norton, 1986), chap. 7.

14. A population of animals can sometimes participate in more than one predator/prey arms race. Lions, for example, may participate in arms races with zebras, wildebeests, gazelles, wild pigs, and others, so that if a group of lions cannot match one of their prey species in a progressive arms race, they might not starve since they have other prey species available.

15. Progress within arms races is not necessarily constant. Changing environmental conditions can cause the arms race to halt, or even go "backward" for periods of time. See Dawkins, *The Blind Watchmaker*, p. 181.

16. Dawkins suggests the idea of a time machine in order to illustrate the progressive changes in particular lineages over time. See Dawkins, *The Blind Watchmaker*, p. 183.

17. The term *Red Queen Effect* used to describe these evolutionary changes was coined by the American biologist Leigh Van Valen. See L. Van Valen, "A New Evolutionary Law," *Evolutionary Theory* 1 (1973): 1–30.

18. Dawkins, *The Blind Watchmaker*, p. 183.

19. Arms races between parasites and hosts involve parasites developing better ways to infect their hosts and the hosts developing improvements in thwarting the parasites. Many plant species have evolved better defenses from herbivores, producing bitter-tasting toxic chemicals such as alkaloids, while the herbivores have evolved detoxifying enzymes, overcoming these defenses.

20. *Empirically* used here means from the point of view of an objective, impartial observer. Mayr, *What Evolution Is*, p. 214.

21. Ibid., p. 278.

22. For an account of evolutionary transitions focusing primarily on changes in the method of information transmission, see J. M. Smith and E. Szathmáry, *The Major Transitions in Evolution* (Oxford: Freeman, 1995).

23. Mayr, *What Evolution Is*, p. 215.

24. E. Mayr, *One Long Argument: Charles Darwin and the Genesis of Modern Evolutionary Thought* (Cambridge, MA: Harvard University Press, 1991), p. 65.

25. Dawkins, "Human Chauvinism," pp. 1018–19.

26. Dawkins explains that an engineer would easily recognize the progressive increase in adaptive features in the improvements in the optical quality of the eye, as it evolved from a simple light-detecting organ. See Dawkins, "Human Chauvinism," p. 1018.