Accepting Change
Or
The Evolution of Common Sense

By Abraham Feinberg

The American biologist Louis Agassiz was one of the foremost scientists of his time, contributing admirably and enthusiastically to the field of natural history until the very day that he died. Yet he was adamantly opposed not only to Darwin's theory of natural selection, but also to the idea of evolution itself. In his book *Essay on Classification*, he made clear his view that species are immutable, writing that they "are reproduced, from generation to generation, with characters identical to the ones that they possessed during their first emergence." It has now been almost a century and a half since the publication of *The Origin of Species*, but this belief in species as unchanging is still widely held. Indeed, the proponents of this perspective often tout their conclusions as resulting from common sense. On what observations, it is worth asking, is this "common sense" based? And what evidence exists in favor of evolution that might contradict this notion?

Evolution, of course, is all about change. Consequently, in order to form an opinion on any evolutionary theory, it is essential to investigate the nature of change in the biological world. That organisms are variable from one generation to the next is a fact that can be confirmed without ever leaving the home. Families, for example, vary from generation to generation. While each child resembles its parents, it is also significantly different. But to what degree does this variation extend? Some argue that the changes within a species are small and that they are constrained within certain limits, meandering in one direction or another, but never resulting in extremes. A daughter may be taller than her mother, but this is within the normal limits of variation and does not lead to some over-all trend of increasing height, for the daughter may very well have offspring that are shorter than herself.

However, variation in organisms does not always oscillate in this fashion, nor remain within such constraints. This can be demonstrated experimentally by means of artificial selection. Again, we need not leave the home for an example. The selective pressures that humans have exerted on the domesticated dog have had such a profound impact that it has developed into some truly bizarre and extreme shapes, many of which share little resemblance with one another, much less with their ancestral form. An even more dramatic example comes from the work of the Russian scientist Dmitri Belyaev and his colleagues, who, over the course of only a few decades, succeeded in transforming a wild species of fox, *Vulpes vulpes*, into a snuggly, colorful, floppy-eared creature that actively seeks out human affection. The variations exhibited in these examples are clearly beyond the normal limits of these species. Thus, it is clear that selective pressures are capable, by small and successive increments, of changing the traits of a species.
Yet it could still be argued that such variations are relatively small when compared to what would be needed for the genesis of an entirely new species. It is one thing to give a fox floppy ears, but are the same forces and principles strong enough to lead from a single-celled organism to all the life that we observe today? Darwin believed that they

were. While Darwin pictured life as interconnected and infinitely malleable, Agassiz asserted that species are distinct and immutable.

It is not difficult to see the appeal of Agassiz's position. It seems, after all, to be supported by even the most casual observation. Merely step outside your front door, for example, and you can see people, trees, dogs, and other organisms that clearly appear to belong to distinct and separate "types" or "species." If Darwin's theory is correct, we might expect to see, rather than distinct species, a smooth spectrum of life, with each organism varying only by slight increments from its closest relative. We might then talk about life in degrees, rather than categories. That is, we might speak of something as being "more mammalian" or "less mammalian," much as we describe a color as "more blue" or "less blue." Such a gradual continuum is what Darwin's theory implies, for natural selection can only change a species from one form to another by means of gradual change. In looking out the front door, no such continuum is observed, and this, perhaps, is why it seems like a matter of common sense that species are static.

But this is most certainly not the end of the matter! A deeper investigation reveals that species are not as unrelated as they at first appear to be. Indeed, our attempts to sort organisms into clear, distinct categories have met with mixed success. The platypus provides a wonderful example, for it combines both mammalian and reptilian characteristics. Like all mammals, it is warm-blooded, has hair, and secretes milk. Yet it rather brazenly bucks this classification with the wholly inconsiderate presence of a reptilian jaw, reptilian shoulders and hips, a lack of mammary glands (milk is, bizarrely, secreted through glands in the abdomen and must be licked off by the young) and a habit of laying eggs that is downright insulting to its designation as a mammal. Indeed, when it comes to the platypus, it really is appropriate to speak in terms of *more mammalian* and *less mammalian*!

Even between clearly distinct species we can see patterns in development and anatomy. The embryos of many animal species share developmental patterns and structures. Moreover, many of the similarities between embryos of different species are still evident in the adults. For instance, the same skeletal structures that develop into the bones of the limbs in humans can be found in a vast array of other animals, being used to support anything from the flippers of whales and dolphins, to the wings of bats.

In this manner, we see how similar structures can serve different functions. Conversely, there are many examples of similar *functions* being arrived at from entirely different *developmental* routes. Bats, birds, and insects all share the ability to fly. Yet the structures they use, while having similar outward appearance and function, are quite different from one another in their underlying development. The fins of fish versus the flippers of dolphins are another clear example of this phenomenon. Why should this happen? Why should a dolphin's flipper serve the same function as a shark's fin, but be developed from the same structure as a human hand?

These physiological mysteries are only increased by a correlation between them and patterns in geographical distribution. Most obviously, where there is geographical isolation, there is often an isolation of physiological traits. Marsupials, for example, are confined almost exclusively to Australia. Other mammals may share a superficial resemblance to marsupials, but none have the same underlying developmental characteristics that unite marsupials as a group. When similar species do exist in multiple locations, they are often found to be more closely similar in developmental structure when they are geographically close. For instance, the Galapagos tortoise is much more similar to nearby South American tortoises than to those of other continents.

It is important to realize how strong these developmental patterns are. Species with the same developmental trends often have the same adult structures as similar species, even when these structures are not fully functional! These structures often resemble normal features of a similar organism's anatomy, but are usually reduced in function and size. A few common examples include wings in flightless birds, pelvic bones in snakes and whales, and wisdom teeth in humans. There is some dispute concerning some of these structures as to whether they are entirely useless or simply serve a reduced function. In that case, consider the example of the blind mole rat, *Spalax ehrenbergi*. This borrowing creature spends the majority of its time underground and so has little use for vision. As a consequence, it is entirely blind—and yet, it does indeed have eyes. These are small, nonfunctional, and are covered by a layer of skin. Why should a species have eyes, yet be unable to see?

To top all of this off, the mechanism of inheritance, which neither Darwin nor Agassiz were able to observe directly, was finally discovered in the latter half of the 21st century. This mechanism, which we call DNA, basically includes all the information that makes an organism what it is. DNA has been studied in great detail and provides yet another direction from which to confirm the relationships described above. As predicted by Darwin's theory, all the above-mentioned patterns of physiology match perfectly with the patterns found in DNA structure. Species with similar developmental characteristics have similar DNA, while those that are isolated from one another and only converge in functionality, tend to have less similar DNA.

These patterns are very congruent with Darwin's theory. In fact, it seems impossible to explain by any other means! There is still, however, one more issue to resolve. We are still left with the apparent difficulty that most organisms are easily divided into highly disparate groups. We still look out from our doorstep and run into that common sense conclusion: that life is at best connected by broken relationships, not a smooth continuum of intermediates. It appears that humans beget humans, blind mole rats beget blind mole rats and so on. While all of the examples given here strongly argue for a gradual evolution of life, we are still left with the problem that we do not *see* the intermediate forms that such an evolution implies.

This, however, is a misconception derived from the nature of the connections between species. For if Darwin was correct, evolution would form a branching "tree" of life that diverges *through time*. By looking only at the organisms that are alive today, we are, in effect, cutting only a thin slice out of this tree. What we see are only disconnected clumps of life, which we consequently classify as distinct species. By looking only at the tips of the branches, we fail to see the incremental connections that curve into the past, merging with one another and forming a seamless evolutionary tree.

Ideally, we could travel into the past, to confirm that these developmental branches do indeed converge. The fossil record makes this possible. If evolution really has occurred, we should find a progression, beginning with a set of homogeneous ancestors, and then gradually branching out into a diverse array of life. After all is said and done, this is perhaps the most conclusive test of Darwinian evolution—and the theory passes with flying colors. Older strata of rocks do indeed contain only very simple, single-celled organisms. These then progress through the higher strata, branching as they go, into a wonderfully complex diversity of life. Many examples, from half-bird, half-dinosaurs to whale-like creatures with legs, provide confirmation of a graduated spectrum. Furthermore, all of the patterns that were detailed above, from the developmental structures to the geographic distribution of species match perfectly with the patterns in the fossil record. Most importantly, there is not a *single* fossil that is incongruent with this pattern.

If Darwin's theory is actually false, it is highly improbable that so many lines of investigation, from so many different fields, would all be consistent with Darwin's theory and that *none* of them would falsify it. That the idea has withstood this assault qualifies it as a rigorously tested scientific theory and one that has earned its place as the status quo. The view of life as static and unchanging is understandable in someone who never steps beyond his or her doorstep, but is no longer a reasonable position for someone who earnestly seeks to understand the natural world. Indeed, it is high time that this idea goes extinct, and that our common sense evolves to accept change.

And if that doesn't convince you…

Say hello to my little friend!

Ehrenberg's Blind Mole Rat
(*Spalax ehrenbergi*)