CHAPTER 1

HUMANKIND'S PLACE IN NATURE

WE HUMAN BEINGS HAVE ALWAYS TAKEN WHO WE ARE PRETTY much for granted. After all, we are so unlike the other living creatures with which we share the world that, on the face of it, there's very little room for confusion. Bizarrely, we walk upright on two legs, freeing up hands that have acquired astonishing powers to manipulate things. We lie to each other using that highly unusual medium we call language. We have vast brains, housed in skulls that are precariously balanced atop rather puny bodies; and we are not at all discomfited by our ability to entertain conflicting beliefs within those brains. We wield amazingly complex technologies, without which we couldn't possibly any longer get by, and we process information in a totally unprecedented fashion. The list of our unique features is endless: nothing else in nature looks or does business anything like us, with the result that for most of its history the idiosyncratic *Homo sapiens* has hardly seen any need to define itself. The differences between us and the other animals around us seem so obvious that, for example, back in the eighteenth century the great lexicographer Samuel Johnson thought it adequate to define a "man" as a "human being," and "human" as "having the qualities of a man." Perhaps this was not the high point of Johnson's magisterial *Dictionary;* but at a time when our closest known relative in

Nature was the poorly understood orangutan, Johnson's contemporaries hardly needed more.

Certainly Johnson's equally famous contemporary Karl Linnaeus didn't. Linnaeus, the father of modern zoological classification, is revered for having taken the bold and revolutionary move of classifying us among the primates, along with the lemurs and the monkeys and the apes. But when it came to actually describing *Homo sapiens,* he abandoned his normal practice of listing features that would help his readers to recognize a member of a particular species if they saw one. Instead, he contented himself with the admonition *nosce te ipsum:* "Know thyself." And perhaps this vagueness was entirely forgivable. After all, while we are dimly aware that we are integrated into the natural world, it is equally evident that, in some complex and occasionally unfathomable ways, we are also set apart from it. We just don't function in quite the same way as other animals do, and for all that we are fundamentally just another mammal species, with hearts and kidneys and gallbladders and a need to eat and breathe, there is undeniably something *different* about us.

The first savant we know of who tried to figure out just how our strange species fits into the world was Aristotle, back in fourth-century-BC Greece. As the earliest comparative anatomist on record, Aristotle was interested in the continuities he perceived among all living forms. He even saw continuity between the animate and inanimate worlds, and was the first to propose that life had been formed from an inert precursor such as pond sludge (which, as shown by the much later invention of the microscope, actually teems with life). Still, the universe Aristotle envisaged was fixed and eternal, its every component fixed in a hierarchy from the simplest to the most complex. On the lowest rungs of the "ladder of being" were rocks and other objects that possessed no life force, but just existed. Above these lay the simplest animate things like plants, with the properties of life, growth, and reproduction. Yet higher up the ladder lay the various animals, with additional capacities such as movement and memory. Highest of all were humans, with the power of reason. Every kind of organism had its particular position on the ladder, and the whole sequence was somehow initiated by a "Prime Mover" whose exact qualities remained ambiguous.

Closer to our own times, Aristotle's arrangement was eagerly seized upon by the Scholastic theologians who dominated medieval Christian thought. With Saint Augustine, these scholars were only too happy to equate Aristotle's prime mover with the biblical God, who presided over a Great Chain of Being in which every living thing occupied its divinely preordained place. Human beings ranked below the various kinds of angels, but above the lions and other savage beasts that lorded it over the meeker domestic animals, and so on, down the line. Just as a physical chain is a continuum that nevertheless consists of discrete links, the Chain of Being connected human beings to the rest of God's creation while also holding them apart from it: a clever ambiguity that helped explain the "rudely wise and darkly great" human condition so admiringly mocked by Alexander Pope in his 1734 *Essay on Man,* still the most penetrating portrait of the human predicament ever penned.

Nonetheless, as early as the sixteenth and seventeenth centuries, naturalists were already trying to refine the Scholastics' ritualized description of the living and inanimate worlds. In the eighteenth century it was Linnaeus's great genius to recognize not only that the living world was clearly structured, but that this structure could best be classified using an arrangement of sets-within-sets. This insight allowed Linnaeus to give us the system of classifying living things we still use, in which our species, *Homo sapiens,* belongs to a genus *Homo* that in turn belongs to the family Hominidae, which forms part of the order Mammalia, and on up until we are united with all Animalia. In this inclusive hierarchy, each category includes everything below it in the scale, so that *H. sapiens* is only one of several species—the others are now extinct—that are classified in the genus *Homo,* while the family Hominidae contains several genera, and so on. This is a significant difference from the military-style hierarchy represented by the Great Chain of Being, in which every species occupies only a single rank. The inclusive Linnaean hierarchy turned out to capture very nicely the pattern of historical events that we now know gave rise to the Tree of Life to which we belong.

In Linnaeus' time, as today, the basic unit into which living things were seen to be "packaged" was the species. As early as the seventeenth century, the English naturalist John Ray had recognized that what gives any species its (occasionally permeable) borders is that it is bound together as a reproductive unit. In today's parlance we would say that, among sexually reproducing organisms, the species is the largest population within which interbreeding can freely take place. Of course, in most cases species are also physically distinct in some way from their close relatives; but because recognizable varieties often exist *within* species that will readily interbreed if and when they get the chance, the key test of species membership is reproductive continuity—whether the members of a group are interested in mating with each other, and can do so successfully. In other words, individuals don't belong to the same species because they look similar; they look similar because they belong to the same species.

Since we human beings are an integral part of the living world, appreciating just where and how we fit into the biota requires not only that we know ourselves through introspection, but that we understand exactly what species are, how we can recognize them, and how they may or may not change over time. This is because, whatever your organism of interest, if you don't first have a reliable family tree that properly links it to its closest relatives and on to the rest of the biota, it is tough to say anything about where it came from. The same thing goes for your expectations about how change has occurred in evolutionary time, because your model of change has to fit the actual facts of history. And, because what we think we know scientifically about the world may change, we forget at our peril that received wisdom—what we were taught—requires continual reexamination.

The one thing the Scholastics had in common with Ray and Linnaeus was the notion of a stable, unchanging universe, in which each species had its own immutable place. But by the time the early years of the nineteenth century came around, some scientists were beginning to have their doubts about this. The toils of early geologists and paleontologists, in particular, were beginning to raise questions about the fixity of both landscapes and fossil species. Sedimentary rocks pile up on each other like layers in a cake, but while you can, with luck, figure out the local succession of strata fairly straightforwardly, correlating them from one place to another can be very tricky because the physical composition of a rock is no guarantee of its age. Faced with this reality, early geologists did not take long to hit on the expedient of using the fossils contained in sedimentary rocks (usually the bones and teeth of vertebrates, or the shells of mollusks and other marine invertebrates) to determine the order in which they were deposited. This is possible because different faunas characterize different periods of geological time—as we now know, because of evolutionary change.

Still, even before ideas of evolution became current, it was already clear not only that the planet Earth has had a very long history, but that it did not always look as it does today. One early way of accounting for the differences observed between ancient and modern faunas without too greatly violating

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religious belief was to view fossil species as the victims of ancient "catastrophes." Analogous to the biblical Flood, such catastrophes were hypothetical events that had carried off entire earlier creations. And in the scant but rapidly accumulating fossil record, there were indeed hints of large-scale faunal replacements. These came in the form of evidence for the very occasional mass-extinction events that saw the sudden disappearance of a large proportion of life forms on Earth. By and large, the biblical faithful (who at least nominally included almost everyone in Europe) found such readings an acceptable fudge; but by the early nineteenth century, new perspectives were beginning to emerge on the causes of faunal change over time.

Despite various earlier rumblings, most modern accounts of how science finally came to grips with the changeability of life over the eons begin with the remarkable Jean-Baptiste de Lamarck. Working principally with mollusk fossils from rocks of the Paris Basin, this great French naturalist was the first to conclude explicitly—as early as 1801, and most influentially in his *Philosophie Zoologique* of 1809—that species, far from being fixed, modify as time passes. To Lamarck, species were genealogical lineages of organisms. Each lineage was discrete, had its own ancient origins, and possessed innate tendencies toward change and greater complexity. And although this standpoint is quite distant from our ideas of evolution today, it did encapsulate the essential notion of change in the natural world, thereby representing a radical break with the traditional views of a static natural world derived from biblical scholarship. Perhaps it is unsurprising that Lamarck was working in the secular environment of postrevolutionary France.

Given the profound implications of Lamarck's central insight for the history of life, it is tragic that it was—and continues to be—overshadowed by his unfortunate choice of mechanism: the notion that lineages modify via the use and disuse of their various anatomical features, as their members actively interact with their environments. A favorite example was the blindness of burrowing moles, although the most familiar is the giraffe's neck, stretched out from generation to generation as ancestral giraffes strove to feed ever higher in the trees. This notion of change is clearly wrong, for virtually none of the significant features an animal might acquire during its lifetime—a heavily muscled physique, for example, or flat feet—is directly or durably passed on to its offspring. But Lamarck's dynamic view does actually incorporate a further element—adaptation to the environment—that has been crucially important in later evolutionary thought. What is more, his view of change was an adaptation of prevailing beliefs based on the observation that environmental conditions might give rise to physical differences, such as the tanning of pale European skin in the tropical sun. Nonetheless, the unfortunate Lamarck has been singled out for ridicule ever since, with the result that the important babies of change and adaptation were rapidly thrown out with the bathwater of acquired-character inheritance.

In 1814, just five years after the appearance of Lamarck's great work, an Italian geologist named Giambattista Brocchi published a magisterial two-volume monograph on the rocks and marine fossils of the Apennine mountain chain in Tuscany. Like Lamarck, Brocchi tried to trace lineages of fossil organisms from successive strata. But although he, too, saw change among his fossils, he drew a very different conclusion. What he perceived was not a picture of steady transformation over time. Rather, the species that Brocchi identified in his fossil samples were relatively stable entities that—just like individual organisms—had births, lifespans, and extinctions. They appeared in the rocks; they persisted; they disappeared. And—again like individuals—they appeared to give rise to descendant offspring, in this case new species. By Brocchi's reckoning, lineages were not eternally separate, as Lamarck had thought: one could give birth to another! Brocchi soon moved on to other geological subjects, and most evolutionary biologists today would have difficulty recalling his name; but my colleague Niles Eldredge has argued persuasively that Brocchi's seminal ideas were an important influence on the young Charles Darwin, to whom we turn next.

WALLACE AND DARWIN

Charles Robert Darwin, probably the most influential biologist of all time, was born in 1809 (as it happened, the publication year of Lamarck's *Philosophie Zoologique*) into a world in which notions of mutability in Nature were already in the air not only in France, but also in his native Britain. Indeed, as far back as the late eighteenth century, Charles' own grandfather Erasmus Darwin had somewhat mystically mused on many of the features of the living world that his grandson later pondered. Here is a taste of those musings, buried deep within the first volume of Erasmus' lyrical medical treatise *Zoonomia,* published in 1794: "Would it be too bold to imagine, that in the great length of time, since the earth began to exist, perhaps millions