Introduction

The ancient Greeks were not evolutionists (Essay 1, "Origins and the Greeks"). It was not that they had an a priori prejudice against a gradual developmental origin for organisms (including humans) but that they saw no real evidence for it. More importantly, they could not see how blind law – that is to say, natural law without a guiding intelligence – could lead to the intricate complexity of the world, complexity serving the ends of things, particularly organisms. This need to think in terms of consequences or purposes, what Aristotle called "final causes," was taken to speak definitively against natural origins.

It was not until the seventeenth century – what is known as the Age of the Enlightenment – that we get the beginnings of evolutionary thinking (Essay 2, "Evolution before Darwin"). This could have happened only if there was something, an ideology, sufficiently strong to overcome the worry about ends. Such an ideology did appear, that of progress: the belief that through unaided effort humans could themselves improve society and culture. It was natural for many to move straight from progress in the social world to progress in the biological world, and so we find people arguing for a full-scale climb upward from primitive forms, all the way up to the finest and fullest form of being, *Homo sapiens*: from "monad to man," as the saying went (Fig. Introduction.1). It was not generally an atheistic doctrine, being more one in line with "deism," the belief that God works through unbroken law. But it did increasingly challenge any biblical reading of the past, and it went against evangelical claims about Providence, the belief that we humans unaided can do nothing except for the sacrifice of Jesus on the cross.

Radical claims like these did not go unchallenged. Critics, notably the German philosopher Immanuel Kant and his French champion, the comparative anatomist Georges Cuvier, continued to argue that final causes stand in the way of all such speculations. Moreover, particularly after the French Revolution, many thought the idea of progress to be both false and dangerous. For this reason, evolution was hardly a respectable notion. It had all of the markings of a "pseudoscience," like mesmerism (the belief in bodily magnetism) or phrenology (the belief that bumps on the skull give clues to psychological traits). It existed as an epiphenomenon of a cultural ideology; it was valued because it was value laden through and through. This is not to say

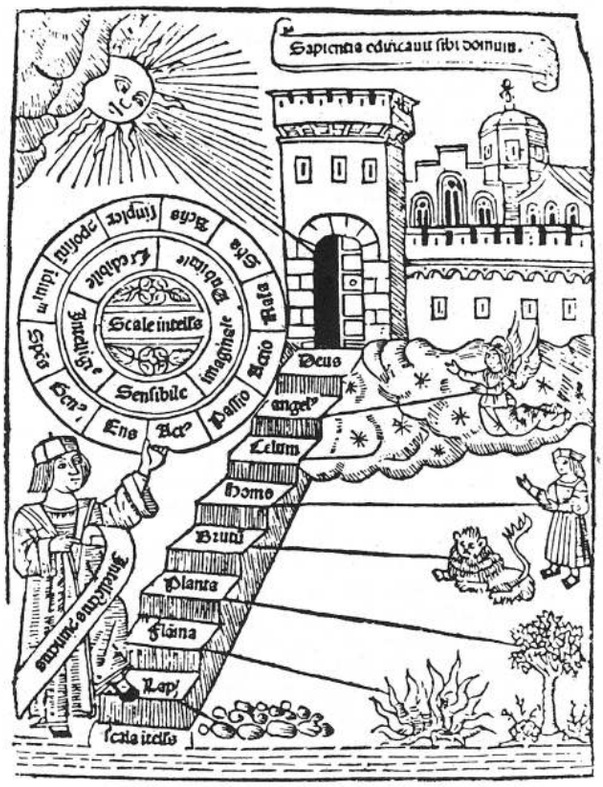

Figure Introduction.1. Particularly popular in medieval times were sketches of the "chain of being," showing the structural order of things, from the simplest of nonliving things (like stones) up to the ultimately important, God. This is from the *Ladder of Ascent and Descent of the Mind* (1305) by the Catalan philosopher Ramon Lull (1232–1315), first printed edition 1512. Although not in itself dynamic, it resonated in the eighteenth century with thoughts of progress and was surely an influencing factor in the thinking of early evolutionists. From M. Ruse, *Monad to Man* (Cambridge, Mass.: Harvard University Press, 1996)

Figure Introduction.2. The anatomist Robert Grant (1793–1874) was an ardent evolutionist and a close acquaintance of Darwin when the latter spent two years in Edinburgh training to be a physician. Darwin was lucky in his teachers and mentors, but clearly he had a nose for picking out those who could instruct and help. Permission: Wellcome

that it was an unpopular idea. As we see in our own day, manifested by such pseudosciences as homeopathy (the belief in the curative power of small doses of the poison that in quantity kills), pseudosciences can be very popular. But enthusiasm lay generally with the public and not with the professional community.

The *Origin of Species* (1859) set out to change all of this. It is important therefore, from the beginning, to get Charles Darwin right. And as a start on this, we must recognize that the autobiography that he penned toward the end of his life, although captivating and very informative, is in many respects highly misleading. Darwin characterizes himself as a charming young man, not terribly directed or motivated, keenest of all on the country sports of shooting and the like, who almost by chance backed into one of the greatest discoveries of all time. This is simply not true. We must keep balance and perspective and not let the English penchant for self-deprecating modesty cloud the story. As an individual, Darwin was genuinely warm and friendly, loyal to family and friends, a good master to his servants, and for all that he was very careful with his money, good at managing it, and generous to those in need. He was loved and with good reason. He was also hard working, even to the point of obsession. He did not have the kind of mind that is good at doing things that impress schoolteachers. He was not that gifted at mathematics, nor was he a brilliant success with languages, dead or living. That put him at a disadvantage, given that back then these were precisely the talents needed for formal academic success. But he was clearly very intelligent; moreover, older people (especially when he went to Cambridge) saw this and almost rushed to be his friends and mentors (see Fig. Introduction.2 and Plate III). Above all, Darwin had an oversized, inventive and discerning eye for a good theory or hypothesis. Added to this is the fact that he was ruthless in his pursuit of an idea and the supporting facts, using others (particularly by courtesy of the penny post introduced in 1840) to gather information for his speculations. He was indeed sick – possibly a psychological sickness but even more possibly purely physical – but he used this sickness to avoid distractions and other commitments. One of his biographers has written of Darwin as having a sliver of ice through his heart, and never were truer words written.[1]

[1] The comment is made by Janet Browne in the introduction to her two-volume biography of Darwin: *Charles Darwin: Voyaging* (1995) and *Charles Darwin: The Power of Place* (2002). In this Introduction, I have relied heavily on this biography for details of Darwin's life and work. I have also used my own earlier writings, including *The Darwinian Revolution: Science Red in Tooth and Claw* (1999a); *Taking*

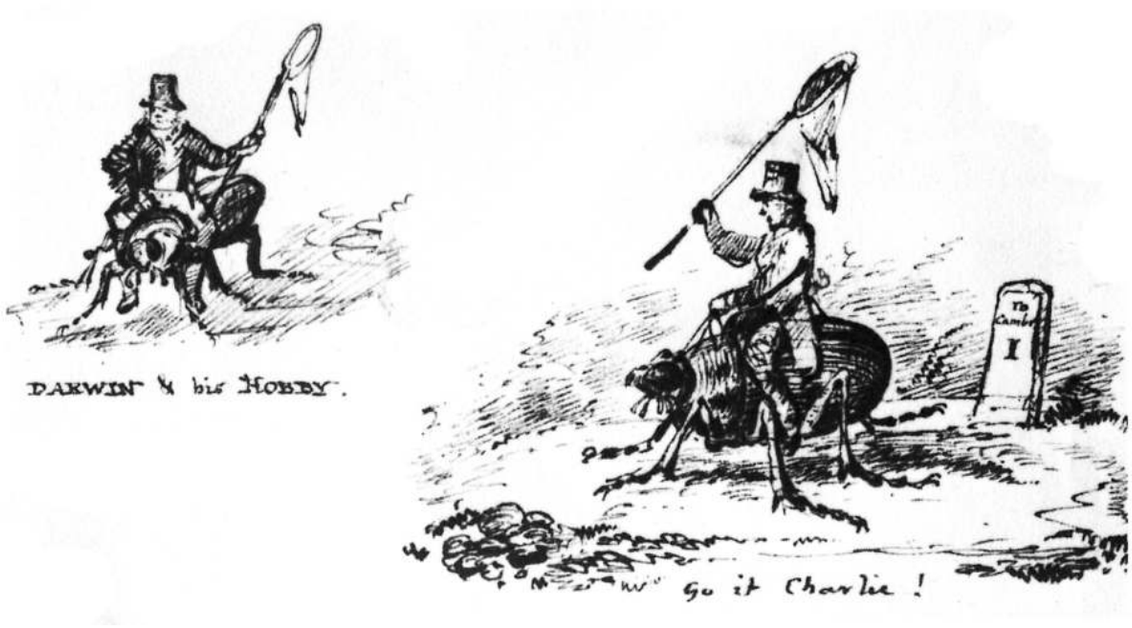

Figure Introduction.3. A cartoon by one of Darwin's fellow Cambridge students (Albert Way) making fun both of Darwin's love of horse riding and of his passion for beetle collecting. Permission: Cambridge University Library

That "Darwin of the *Beagle*" became "Darwin of the *Origin*" was no mere chance. The abilities and drive meshed smoothly with Darwin's background and training. There was a great deal of money in the Darwin-Wedgwood family, and it was kept that way by the frequent intermarriages of which Charles Darwin and his cousin Emma Wedgwood were but one instance. Father Robert was a physician and also a very shrewd businessman, arranging mortgages between those with money to lend (generally industrialists) and those with need of money (often aristocrats with land to provide security). Maternal grandfather Josiah Wedgwood was the founder of the great pottery works, one of the biggest successes in the Industrial Revolution (see Plate IV). Charles inherited the cash, and one immediate payoff was that he never had to work formally to make a living. Not for him the boring jobs of marking papers and sitting on departmental committees. Darwin also inherited much that led to the making of the cash. He was no country bumpkin, nor was he (for all that he had been intended for the church) an ethereal scholar with thoughts fixed only on abstruse points of logic or theology. Science and technology lay behind the revolution, and it was this that grasped Charles Darwin from the beginning. From their earliest days, he and his older brother Erasmus were junior chemists with their own garden-shed laboratory. Then both at Edinburgh and increasingly at Cambridge, Darwin immersed himself in the biological sciences of the day – collecting, reading, listening to others, and attending courses pertinent to these interests (Fig. Introduction.3).

The earth sciences he also pursued, an area of inquiry that was growing and thriving by leaps and bounds. Industry demands fuel, coal now that the trees were vanishing, and materials, iron, copper, and the like. It also has need of transportation, initially waterways, including man-made canals, and then in the nineteenth century the highly successful railway system. All of this demands knowledge of the rocks. No serious businessman wants to invest in a mine that might come up dry after vast expenditures. Equally, no serious businessman wants great effort made to drill tunnels through solid granite when a system of locks going up or around would be much cheaper. Geology holds the key to understanding what exists beyond direct sight, and by the time that Darwin was an undergraduate at Cambridge, the science was a ferment of action and discovery and controversy. That there was a frisson of worry about the time demands of the earth sciences, and the time restrictions of scripture read conservatively, added to its interest – especially given that, almost to a man, the Cambridge professors had to be ordained members of the Church of England.

It was entirely natural that when Darwin set off on the *Beagle* voyage – itself an opportunity to naturalize in new and strange parts of the world – geology should have been something foremost in his mind (Essay 3, "Charles Darwin's Geology: The Root of His Philosophy of the Earth"). It was

Darwin Seriously: A Naturalistic Approach to Philosophy (1986); *Monad to Man: The Concept of Progress in Evolutionary Biology* (1996); *Mystery of Mysteries: Is Evolution a Social Construction?* (1999b); *Can a Darwinian Be a Christian? The Relationship between Science and Religion* (2001); *Darwin and Design: Does Evolution Have a Purpose?* (2003a); *The Evolution-Creation Struggle* (2005); *Darwinism and Its Discontents* (2006); *Charles Darwin* (2008); *Philosophy after Darwin: Classic and Contemporary Readings* (2009c); and *The Philosophy of Human Evolution* (2012).

an exciting time to take up the subject, for opinion (in Britain) was starkly divided, between those (the "catastrophists" represented by one of Darwin's Cambridge mentors, Adam Sedgwick, professor of geology) who thought that every now and then the earth is shaken up by huge earthquakes and the like (after which organisms are created, miraculously, anew) and those (the "uniformitarians" represented by Scottish lawyer-turned-geologist Charles Lyell) who thought that ongoing regular processes, like rain and snow and deposition and erosion, suffice to create the earth's geological history. Lyell had just started publishing his *Principles of Geology* (1830–33), and Darwin devoured it and believed. It was ever the basis for his thinking about earth history and was the foundation of the three books on geology that Darwin published in the ten years after the *Beagle* voyage. No doubt time alone on the ship and the independence forced upon him by the distance from the British scientific community was significant, both in his thinking about geology and also on his mind frame as he now started to work toward the problem of organic origins.

That Darwin, in the mid-1830s – always remember that it was in this decade that Darwin did his creative work, not the future decade of the 1850s when he finally published – was interested in organic origins is no surprise at all. The Cambridge professors loathed and detested evolution, thinking it would subvert both science and religion – they were themselves treading a rather fine, delicate line with their fondness for science and so had to insist to the orthodox that religiously they were purer than pure. Like Mr. Dick in *David Copperfield*, evolution was their King Charles's Head. They could not stay away from the topic. A bright young entrant like Darwin had to sense that there was something of interest here – a sense that would be confirmed when (in 1836) the leading astronomer and philosopher of science John F. W. Herschel wrote to Lyell (in a letter that became public) that origins is the "mystery of mysteries" (Cannon 1961). That it was Charles Darwin of all people who became an evolutionist (the usual word was "transmutation," and "evolution" became generally used for organic origins only in the 1850s and 1860s) is less of a surprise than it might have been. His father's father, Erasmus Darwin – physician, inventor, friend of business – was an ardent evolutionist, and as a youth Charles Darwin had read his grandfather's major work, *Zoonomia*. (Volume 1 was published in 1794 and Volume 2 in 1796. It is in the first volume that the evolutionary speculations occur.) (Fig. Introduction.4). Then, when at Edinburgh, Darwin had been close to one of the very few open evolutionists in Britain at that time, the anatomist Robert Grant. Finally, thanks to Lyell – who gave a detailed exposition in the second volume of his *Principles* – Darwin knew in detail about the evolutionary theory of the Frenchman Jean Baptiste de Lamarck. (Lyell introduced the theory to criticize it. More than one, including Darwin's contemporary and fellow evolutionist Herbert Spencer, read Lyell and was converted to evolution!)

It is always nice and romantic to suppose that new ideas demand a Road to Damascus experience. Probably for Darwin,

Figure Introduction.4. Erasmus Darwin (1731–1802) was one of the early evolutionists. His *Zoonomia* was widely read, including by his grandson Charles. This is a copy of a painting from 1770 by Joseph Wright of Derby. Permission: Wellcome

becoming an evolutionist was a bit more gradual. There is no question but that major influences, along with the geology that was making him think about the operation of laws in nature and implications for such things as time and place, were the fossils that he was collecting on the *Beagle* trip. His finds were almost forcing him to think about origins and changes and causes, and Darwin said as much in his autobiography. We must not exaggerate. Again we see that the young Darwin was, from the first, right in the heart of science in a full-time and professional way. Yet, Darwin was not as skilled and knowledgeable a paleontologist as he was geologist (Essay 4, "Looking Back with 'Great Satisfaction' on Darwin's Vertebrate Paleontology"). It is a field that demanded more biological knowledge than he had in those early years. But equally he was no mere tyro, and certainly, when he returned to England, he was keen to get the best authorities to study his findings – an ambition speaking not just to his own knowledge and abilities but also to his rapidly rising status in the scientific community as one who could expect and get the leaders in the field to work with or for him. Richard Owen, anatomist and paleontologist, was the obvious choice, and (given the quality and freshness of the fossils) it was clearly in the interests of both when Owen did work on Darwin's collection. There is a poignant paradox here, for later it was Owen who became the outstanding opponent of the Darwinians and their theorizing. At first, however, Darwin and Owen were friendly, and although Owen always had yearnings for more metaphysical, German-influenced readings of life's history, one suspects that the two may well have discussed origins and transmutation, not necessarily in an entirely hostile fashion (Rupke 1994). One thing always to be kept in mind is that Owen never had Darwin's privileged

start in life or financial independence. He was in the thrall of men who hated evolution. Later, when he himself moved to a public evolutionary stance, one has trouble seeing if his big complaint with the Darwinians is that they are wrong or that they have stolen ideas that he (Owen) had all along.

Along with the fossils, Darwin was certainly set on the path to evolution by the distributions of the organisms – birds and reptiles particularly – that he saw when the *Beagle* in 1835 visited the Galapagos Archipelago in the mid-Pacific. Even more certainly, his thinking solidified early in 1837 when the taxonomist studying his bird collection confirmed that from island to island there are genuinely different species. It was at this point Darwin opened a series of private notebooks (the key species notebooks are B through E, and the key human notebooks are M and N) and jotted down thoughts on evolution. And its causes! Darwin was a graduate of the University of Cambridge, the home two hundred years previously of the great Isaac Newton. Again and again Darwin's mentors stressed that Newton's overriding achievement was to provide causal understanding of the major advances in physics in the Scientific Revolution. Kant, in his *Critique of Judgement* (1790), had denied that there could be a "Newton of the blade of grass." Darwin, determined to show him wrong, set out deliberately to find the cause of evolutionary change, the biological equivalent of Newton's law of gravitational attraction.

The key insight leading to the discovery of the mechanism of natural selection, the systematic differential reproduction of organisms brought on by the limited supplies of food and space, came late in September 1838. It was then that Darwin read the *Essay on a Principle of Population* (1826) by the Reverend Thomas Robert Malthus, who argued the population pressures in humans lead to inevitable struggles for existence. Darwin generalized to all species – actually Malthus mentioned that he got his inspiration from a more general discussion by, of all people, Benjamin Franklin – and then argued that success in the struggle will (on average) be a function of the different variations of the competitors and that this will lead to ongoing change – change moreover of a particular kind, namely in the direction of features or characteristics (like the hand and the eye) that aid their possessors. In other words, this process of natural selection (the term is not used for another two or three years) produces contrivances or adaptations, things that seem as if designed for the ends they serve. That is to say, the process or mechanism gives a natural (in the sense of working according to blind, unguided law) explanation of Aristotelian final causes. There is no need to suppose outside, divine intervention.

Thanks to the notebooks, we can map in some detail the exact route to discovery of the mechanism and the thinking that came thereafter (Essay 5, "The Origins of the *Origin*: Darwin's First Thoughts about the Tree of Life and Natural Selection, 1837–1839"). In a sense, though, we do have somewhat of an embarrassment of riches, especially when you add in our possession of many of the pertinent works that Darwin read (and annotated extensively) at that time. This has led to some controversy about what the later Darwin said, especially in his autobiography, about his discovery and what the jottings seem to reveal. Particularly there are questions about the exact role played in the discovery by the analogy with artificial selection, the ways in which agriculturalists and fanciers choose the specimens they favor and use as breeding stock. Darwin claimed that it was this that led directly to natural selection, but the notebooks (a reading endorsed by the essay given) suggest otherwise. Perhaps the answer is somewhere in the middle. Darwin was certainly conscious of artificial selection and its importance – an industrial revolution demands an agricultural revolution, to feed the workers, and Shrewsbury is in the heart of rural Britain (and the Wedgwoods particularly were interested in breeding) – but whether it played quite the direct role in discovery might be doubted. What is certainly the case – pointed out in no uncertain fashion to Darwin after the *Origin* was published – is that others had also hit on the notion of natural selection. Darwin at this time even read a pamphlet toying with the idea and noted it. He read: "A severe winter, or scarcity of food, by destroying the weak and unhealthy, has all the good effects of the most skilful selection." About this (in the margin), showing that he sees that something pertinent is at work here although he still doesn't quite get the full analogy, Darwin wrote: "In plants man presents mixtures, varies conditions and destroys, the unfavourable kind – could he do this last effectively and keep the same exact conditions for many generations he would make species, which would be infertile with other species." What does seem to be true is that only Darwin was exploring the possibility that selection could lead to full-blown, permanent change. Others deserve a footnote and little more. (The pamphlet is by Sir John Sebright, a noted breeder mentioned in the first chapter of the *Origin*. See Ruse 1975b.)

A mechanism is not a theory. The public Darwin was getting married and starting a family, falling sick, and working and publishing frenetically on geology (Fig. Introduction.5). The private Darwin was thinking furiously and by 1842 felt sufficiently confident to put his ideas on paper in a 35-page preliminary essay (usually known as the "Sketch"), and then some two years later in 1844 he expanded his ideas to a much longer, 230-page essay (usually known as the "Essay.") We know that he did show material to a young botanist, Joseph Hooker (to become one of Darwin's lifelong friends and a source of much material, physical and intellectual), and he left a note to his wife arranging for publication were he to die prematurely – something he thought quite possible. But that was it, and now the flat-out activity rather slowed as Darwin – the professional, public Darwin – turned increasingly away from geology and toward the life sciences. Obviously, they had always been part of his work and life: the fossils, the Galapagos (and many South American) specimens, both animal and plant, and more. Classification, what biologists call "taxonomy," was both a vital tool and (certainly for the private evolutionist) a great font of inspiration. In the century previously, the great Swedish biologist Linnaeus had formulated the basic principles of classification (the "Linnaean system"),

Figure Introduction.5. In 1842 Charles and Emma Darwin moved to Down House, which Darwin's father bought for the young couple for £2,200. They immediately set about making renovations and additions. Darwin lived here for the rest of his life. From H. E. Litchfield, *Emma Darwin, Wife of Charles Darwin: A Century of Family Letters* (Cambridge: privately printed by Cambridge University Press, 1904)

where organisms are assigned hierarchically to nested sets of ever-greater power and generality – from species at the lowest basic level to kingdoms at the highest. For Darwin, especially for a Darwin whose thinking about evolution was ever influenced by those Galapagos organisms hopping from island to island and changing as they went and thus bringing a treelike history to life (very unlike Lamarck's parallel upward progressions), it was almost a truism that his developmental thinking was the explanation of the fanlike, distributive pattern that epitomized Linnaeus's system (Essay 6, "Darwin and Taxonomy").

It is very probable that it was taxonomic thinking that pushed Darwin to what he considered the major conceptual addition to his theory – the "principle of divergence" – that occurred in the years from the "Essay of 1844" to the *Origin*. Why should there be the range of different forms that we find? Is it just accidental, or is there a deeper reason? In the notebooks, things seem to happen almost by default. "The enormous number of animals in the world depends on their varied structure and complexity; hence as the forms became complicated, they opened fresh means of adding to their complexity; but yet there is no necessary tendency in the simple animals to become complicated although all perhaps will have done so from the new relations caused by the advancing complexity of others" (Barrett et al. 1987, 422–3, E, 95). Then, Darwin saw how this all comes about by selection, because it is advantageous to organisms to differ from potential competitors and thus occupy different niches reducing conflict. "The same spot will support more life if occupied by very diverse forms.... Each new variety or species, when formed will generally take the place of and so exterminate its less well-fitted parent. This, I believe, to be the origin of the classification or arrangement of all organic beings at all times. These always *seem* to branch and sub-branch like a tree from a common trunk; the flourishing twigs destroying the less vigorous, – the dead and lost branches rudely representing extinct genera and families" (Darwin 1985–, 6:448–49, letter to Asa Gray, 5 September 1857) (see Fig. Introduction.6).

Publicly taxonomy was now at the fore, as Darwin plunged into what was going to be an eight-year-long study of barnacles, marine invertebrates that had first captured his fancy when on board the *Beagle* (Essay 7, "Darwin and the Barnacles"). This took him right into the next decade and apparently in some quarters made him a bit of a figure of fun, as the archetypal scientist-scholar who devotes his whole life to the study of something that to the layperson seems of unbelievably trivial importance. But why did Darwin, the ambitious Darwin, go off at this tangent? Why barnacles indeed? Although there are comments and moves made that make for fascinating significance, given our knowledge that Darwin was now an

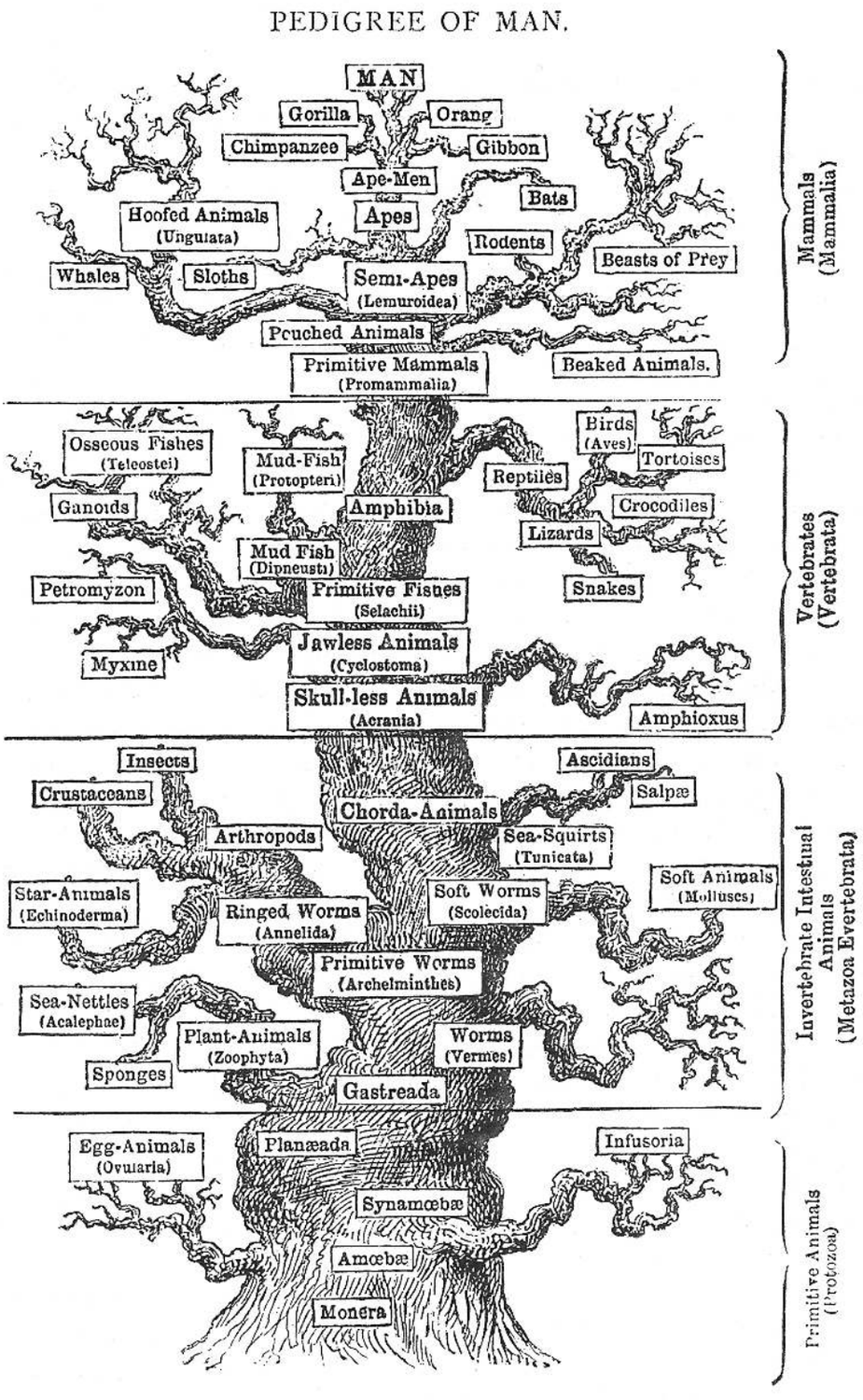

Figure Introduction.6. The tree of life as drawn later in the nineteenth century by Darwin's great German supporter Ernst Haeckel. Note how thoroughly progressionist it is, with simple forms at the bottom (monads) and humans at the top (man). Haeckel used the term "monera," referring to prokaryotes, single-celled organisms without a nucleus. From E. Haeckel, *The Evolution of Man* (New York: Appleton, 1897)

evolutionist, he could not – he certainly did not – come out and profess the convictions that he thought made causal sense of his work. Why did Darwin delay? Why did he not publish the "Essay of 1844"? The note to his wife made it clear that Darwin wanted his thinking made public at some point. Like his sickness, there are as many answers as people who ask the question. Probably various factors were involved. He was sick and felt unable to fight vigorously for his ideas. He never really expected the delay to be so long – twenty-plus years from the Malthus moment to the appearance of the *Origin*. The barnacle studies just stretched and stretched, and the years went by. Most importantly, the public work of the 1830s had paid off. His mentors who had pushed his career were seeing their efforts rewarded. By the mid-1840s Darwin was established as a serious and important scientist. He was cherished by the community, especially by the Cambridge professors and their set who had helped him launch his career. And here's the rub. They went on hating evolution – Cuvier was their scientific hero – and someone going that way would be criticized and ostracized. Added to this, 1844 was the year that the Scottish publisher Robert Chambers published (anonymously) his *Vestiges of the Natural History of Creation*, a pro-evolutionary work that was anathematized by the scientific establishment (as it was equally lauded by the uninformed and ignorant). Darwin, whose great public success was now being reinforced by the general and enthusiastic reception of a book (the *Voyage of the* Beagle) based on his travel years, had no desire to put all in jeopardy.

Finally, however, particularly at the urging of friends who gradually were being let into the secret – after Hooker came Lyell and then in England the young anatomist Thomas Henry Huxley (grandfather of the novelist Aldous Huxley), reinforced in America by the Harvard botanist Asa Gray – Darwin started work on a massive volume, intended to overwhelm with fact and footnote. Huxley always praised Darwin for the delay, arguing that the barnacle work gave him invaluable understanding and experience of the organic world. There may be some truth in this, although one cannot honestly say, despite the principle of divergence, that the differences between the "Essay of 1844" and the *Origin* seem worth quite such a wait and effort. What was important was the growing status and the new network surrounding Darwin, a network that was going to be much more inclined than the older Cambridge set to accept and promote his ideas. But also Darwin did work hard in the 1850s on the empirical evidence for his evolutionary thinking, doing, for instance, careful experiments on the survivability of seeds in salt water, a crucial piece of information for his claims about how organisms could spread around the world, given the barriers of the oceans. (Remember, we are a hundred years too early for plate tectonics.) And it is clear that, whatever may have been the truth back in the late 1830s, by the 1850s the analogy with artificial selection was growing increasingly in his mind. He was delving carefully into the successes of breeders and judging the relevance to his concerns. What does seem probable, and perhaps we should not really be that surprised, is that Darwin was himself fairly selective in this direction, picking out precisely those results that were favorable to his thinking and glossing over those that were not (Essay 8, "The Analogy between Artificial and Natural Selection").

Then came the thunderbolt. In the summer of 1858, Alfred Russel Wallace, a young naturalist and professional collector, formerly in Brazil and now in the Far East, someone with whom Darwin had been corresponding, sent to Darwin (of all people) a short essay with exactly the same ideas that had been fermenting for nigh twenty years (Fig. Introduction.7). Friends, Lyell and Hooker, came to the rescue. Wallace had to be acknowledged but there must be no nonsense about Darwin's priority and so, along with Wallace's essay, pertinent extracts from the "Essay of 1844" and the already-quoted, informative letter sent to Asa Gray (about the principle of divergence) were published in the *Proceedings of the Linnaean Society of London*. Then Darwin sat down to write an overview of his theory. Thus it was that, in the late fall of 1859, the *Origin of Species* arrived on the scene.

Read the essay on the *Origin* in the light of what it is trying to do (Essay 9, "The *Origin of Species*"). It is taking seriously Darwin's own comment that the book contains "one long argument" and is setting out to show the nature of that argument. Because it is exposing the conceptual skeleton of the *Origin* rather than trying to give a full synopsis of the work, one should use the essay as a map to more detailed discussions in later essays, for instance about species or sexual selection or heredity. Note how Darwin runs together the argument for evolution (and the tree of life) and the argument for the mechanism of natural selection. One point of interest will be the extent to which readers separated out these two aims. Darwin never talks explicitly in the *Origin* about those whom he is opposing, those who argue for some kind of non-natural creation of life. Although there were biblical literalists (like today's American creationists) back then, these are not his target. He has in mind real, respectable scientists, like his old friend Adam Sedgwick, professor of geology at Cambridge and, perhaps reaching even further back, the great French anatomist Georges Cuvier. More immediately, the Swiss-born, American-transplant, ichthyologist and geologist (expert on glaciers and their effects) Louis Agassiz would have been in his sights – particularly in light of his neo-Cuvierian *Essay on Classification* published in 1857. Agassiz sent Darwin a copy. In a letter of 13 March 1859, Darwin wrote to Huxley, who admittedly liked to hear these sorts of things, that it was "utterly impracticable rubbish" (Darwin 1985–, 7:262).

Given the central importance of the *Origin*, we must turn and consider in some detail aspects of the argumentation given in the work. The obvious place to start is with the mechanisms of change. Darwin always thought that, although natural selection is by far the most important mechanism of evolutionary change, it is by no means the only one. The major alternative was always a secondary form of selection, so-called sexual selection (Essay 10, "Sexual Selection") This appears even in the "Sketch of 1842," so it is not some late "add on," although it is not until he comes to write his major work on

Figure Introduction.7. Alfred Russel Wallace (1823–1913), the co-discoverer of natural selection, in 1853. He was already an ardent evolutionist. From A. R. Wallace, *My Life* (London: Chapman and Hall, 1905)

our species, *The Descent of Man and Selection in Relation to Sex*, that Darwin gives the mechanism extended treatment. Whereas natural selection involves a struggle against the elements and other organisms for space and food and the like, leading to reproduction, sexual selection occurs only within species and is a function of competition for mates.

Given, whatever the exact relationship, the central importance in Darwin's thinking of the analogy between artificial and natural selection, it is surely plausible to think that Darwin founded his distinction between the two kinds of selection on the distinction one finds in the world of the breeders, between those selecting for profit – fatter pigs, shaggier sheep – and those selection for pleasure – more tuneful birds and fiercer dogs. This supposition gains further strength when one finds that Darwin divided sexual selection into two kinds: selection between males through conflicts for females ("male combat") and selection by females for more desirable males ("female choice") – thus the magnificent antlers of the stag and the gorgeous feathers of the peacock, respectively. These correspond – and Darwin points out the correspondence – to breeders selecting for fighting spirits in their dogs and cocks and breeders selecting for prettier feathers on their budgerigars and like pets.

What is particularly interesting is the fate of sexual selection over the years. Initially, most people inclined to think with Alfred Russel Wallace that truly the distinction is not that significant – certainly not sufficiently significant to overcome worries that the whole process seems fatally anthropomorphic. Why should one suppose that peahens have the same standards of beauty as humans? Starting in the 1960s, however, particularly with the rise of sociobiology (of which more later), sexual selection has come to play a larger and larger role in the thinking of evolutionists. It is thought to be a really significant aspect of the biological world. Darwin, as we shall see, thought it very important in the context of humans, an assumption as controversial then as it is now. Remember that selection (of whatever kind) leads not just to change but to change of a particular kind, namely adaptive change. Put this in the context of the sexual selection of human beings, and you are plunged right into discussions about male-female differences and whether they are natural (meaning biological) or cultural (meaning more environmental). But whether sexual selection is accepted or whether it is rejected, it is realized that it cannot be ignored, and for this reason, if for no other, demands careful and explicit scrutiny.

A lot of not-always-tremendously-helpful things are said about the *Origin*, at the head of which list is the claim that the work is mislabeled because it is not about the origin of species at all. It is true that the work is basically on evolution and its major mechanism of natural selection, but there is much on species, their nature and their causes. What else is the principle of divergence but an attempt to show why the world comes cut up at the joints, to use a phrase of Plato? It is obvious that Darwin is going to have some tricky discussion about the nature of species. On the one hand, he wants them to be things that are real enough to merit discussion about natures and causes. On the other hand, he wants them not to be so fixed that they cannot change and evolve. Some or all are in constant motion and change. So there is a paradox of a kind here, but it is not mysterious and not in Darwin's opinion beyond understanding. What is surely true is that often discussion of the topic has been clouded by later proposals about species, not to mention enthusiasts' eagerness to claim Darwin as one of their precursors – or conversely, to promote their own importance by contrasting their successes with Darwin's supposed failures (Essay 11, "Darwin and Species").

This much we can say, that Darwin surely thought that species are real in some sense. There may be many borderline cases – one hopes that there are borderline cases! – but species are real. We can also say that Darwin was keenly aware that reproductive isolation is an important part of the story. Cabbages and humans don't share offspring. However, there is little doubt that Darwin was unwilling (unlike many taxonomists in the twentieth century) to put the entire burden on reproductive isolation. He thought it broke down too often to be reliable. Also, he was worried about the role of selection in reproductive isolation. Or, rather, he was not so worried about its role – he didn't think it was there when it came to producing hybrid sterility – but about the consequences for such issues as the reality of species. As we shall see shortly, factors like these take us to the heart of some of the most difficult and contentious issues surrounding natural selection, so there is hardly any surprise that Darwin's thinking on the species issue generally causes differences of opinion. These started as soon as he published and continue to this day. If ever proof was needed that scientific understanding is more than simply determining matters of brute fact, demanding also philosophical and like (including historical) judgments, the species problem provides it.

The most (deservedly) influential work in the twentieth century about scientific change was Thomas Kuhn's *The Structure of Scientific Revolutions*. Well known is Kuhn's notion of a "paradigm," a kind of way of thinking within which scientists do all of their work ("normal science") almost all of the time. Equally well known is the claim that sometimes paradigms break down and there is a switch to a new one, a switch not entirely rational and much akin to a political or religious conversion, after which science resumes its normal state and work proceeds now in the new paradigm. I don't think anyone would deny that something of this nature went on in the Darwinian Revolution. Darwin's teachers and elders, men like Adam Sedgwick and William Whewell, really did see the world in one way, and Darwin's followers like Joseph Hooker and Thomas Henry Huxley really did see the world in another way. It is comforting to say that one side is wrong and the other side is right, and in a way this is certainly true. But it is not quite all of the truth. Sedgwick and Whewell were as bright and informed as Hooker and Huxley. A kind of conversion experience had occurred.

Having said this, it is clear that Kuhn often tells only part of the story, and this is certainly true in the Darwinian case. The impression certainly is that everything happens once and