rely upon mystical guiding forces or upon genetically impossible transformations, a philosophical materialist like Charles Darwin would call it rubbish.

Until now I have avoided discussing the fossil evidence in order to concentrate on the theoretical and experimental difficulties that surround the reigning neo-Darwinist synthesis. But evolution is at bottom about history; it aims to tell us what happened in the past. On that subject the fossils are our most direct evidence, and it is to them that we turn next.

Chapter Four

The Fossil Problem

TODAY IT IS widely assumed that the existence of fossil remains of numerous extinct species necessarily implies evolution, and most people are unaware that Darwin's most formidable opponents were not clergymen, but fossil experts. In the early nineteenth century the prevailing geological theory was the "catastrophism" advocated by the great French scientist Cuvier, the father of paleontology. Cuvier believed that the geological record showed a pattern of catastrophic events involving mass extinctions, which were followed by periods of creation in which new forms of life appeared without any trace of evolutionary development.

In Darwin's time, Cuvier's catastrophism was being supplanted by the uniformitarian geology advocated by Darwin's older friend Charles Lyell, who explained spectacular natural features as the result not of sudden cataclysms, but rather the slow working over immense time of everyday forces. In retrospect, an evolutionary theory of the Darwinian kind seems almost an inevitable extension

changed in whole units, and to accomplish this "you need to do more than just shove in an extra bone," because each vertebra has associated with it a set of nerves, blood vessels, muscles, and so on. These complicated parts would all have to appear together for the extra vertebrae to make any biological sense, but "it is easy to believe that individual snakes with half a dozen more vertebrae than their parents could have arisen in a single mutational step." This is easy to believe, according to Dawkins, because the mutation only adds more of what was already there, and because the change only appears to be macromutational when we look at the adult. At the embryonic level, such changes "turn out to be micromutations, in the sense that only a small change in the embryonic instructions had a large apparent effect in the adult."

Gould supposes what he has to suppose, and Dawkins finds it easy to believe what he wants to believe, but supposing and believing are not enough to make a scientific explanation. Is there any way to confirm the hypothesis that mutations in the genes which regulate embryonic development might provide whatever is needed to get evolution over the unbridgeable gaps? Creatures that look very different as adults are sometimes much more alike at the early embryonic stages, and so there is a certain plausibility to the notion that a simple but basic change in the genetic program regulating development could induce an embryo to develop in an unusual direction. In principle, this is the kind of change we might imagine human genetic engineers to be capable of directing one day, if this branch of science continues to advance in the future as it has in the recent past.

Suppose that, following a massive research program, scientists succeed in altering the genetic program of a fish embryo so that it develops as an amphibian. Would this hypothetical triumph of genetic engineering confirm that amphibians actually evolved, or at least could have evolved, in similar fashion?

No it wouldn't, because Gould and the others who postulate developmental macromutations are talking about *random* changes, not changes elaborately planned by human (or divine) intelligence. A random change in the program governing my word processor could easily transform this chapter into unintelligible gibberish, but it would not translate the chapter into a foreign language, or produce a coherent chapter about something else. What the proponents of developmental macromutations need to establish is not merely that there is an alterable genetic program governing development, but that important evolutionary innovations can be produced by random changes in the genetic instructions.

The prevailing assumption in evolutionary science seems to be that speculative possibilities, without experimental confirmation, are all that is really necessary. The principle at work is the same one that Waddington, Medawar, and Mayr invoked when challenged by the mathematicians. Nature must have provided whatever evolution had to have, because otherwise evolution wouldn't have happened. It follows that if evolution required macromutations then macromutations must be possible, or if macromutations are impossible then evolution must not have required them. The theory itself provides whatever supporting evidence is essential.

If the Darwinists are at all uncomfortable with this situation (actually, most of them don't seem to be), the anti-Darwinists are in no better shape. The great geneticist Goldschmidt was reduced to endorsing a genetic impossibility, and the great zoologist Grassé could do no better than to suggest that evolving species somehow acquire a new store of genetic information due to obscure "internal factors" involving "a phenomenon whose equivalent cannot be seen in the creatures living at the present time (either because it is not there or because we are unable to see it)." Grassé was all too aware that such talk "arouses the suspicions of many biologists . . . [because] it conjures up visions of the ghost of vitalism or of some mystical power which guides the destiny of living things. . . ." He repeatedly denied that he had anything of the sort in mind, but suspicions of vitalism once aroused are not conjured away by bare denials.

We can see from these examples why neo-Darwinism retains its status as textbook orthodoxy despite all the difficulties and even the imputations of moribundity. If neo-Darwinist gradualism were abandoned as incapable of explaining macroevolutionary leaps and the origin of complex organs, most biologists would still believe in evolution (Goldschmidt and Grassé never doubted that evolution had occurred), but they would have no *theory* of evolution. Materialist scientists are full of scorn for creationists who invoke an invisible creator who employed supernatural powers that cannot be observed operating in our own times. If evolutionary science must also

We have to do all this supposing, according to Gould, because it is just too hard to "invent a reasonable sequence of intermediate forms—that is, viable, functioning organisms -between ancestors and descendants in major structural transitions." In the end we will have to accept "many cases of discontinuous transition in macroevolution." The kind of small genetic alteration which Gould had in mind (and said Goldschmidt had in mind) was a mutation in the genes regulating embryonic development, on the theory that "small changes early in embryology accumulate through growth to yield profound differences among adults." Indeed they must do so, because otherwise Gould could not see any way that major evolutionary transitions could have been accomplished.

Gould published a major article in the scientific journal *Paleobiology* which expressed his endorsement of Goldschmidt even more explicitly, and in which he pronounced the effective death of the neo-Darwinian synthesis. In place of the dead orthodoxy he hailed as "the epitome and foundation of emerging views on speciation" a passage by Goldschmidt which insisted that "neo-Darwinian evolution . . . is a process which leads to diversification strictly within the species. . . . The decisive step in evolution, the first step towards macroevolution, the step from one species to another, requires another evolutionary method than the sheer accumulation of micromutations." With respect to the evolution of complex organs, Gould disavowed reliance on "saltational origin of entire new designs," but proposed instead "a potential saltational origin for the essential features of key adaptations." In short, he tried to split the difference between Darwinism and Goldschmidtism.

And so the hopeful monster returned, but its hopes were soon disappointed once again. Ernst Mayr, the most prestigious of living neo-Darwinists, wrote that Gould had entirely misrepresented Goldschmidt's theory in denying that Goldschmidt advocated impossible, single-generation systemic macromutations. "Actually, this is what Goldschmidt repeatedly claimed. For instance, he cited with approval Schindewolf's[2] suggestion that the first bird hatched out of a reptilian egg. . . ." Mayr thought that some mutations with large

[2] Otto Schindewolf was a prominent paleontologist whom we will encounter again in the next chapter.

scale effects might be possible,[3] but he could find no evidence that any great number of them had occurred and he saw no need to invoke them because he considered the mechanisms of neo-Darwinism capable of explaining the emergence of evolutionary novelties.

Richard Dawkins wrote scornfully of Goldschmidt in *The Blind Watchmaker*, and criticized Gould for trying to rehabilitate him. For Dawkins, "Goldschmidt's problem . . . turns out to be no problem at all," because there is no real difficulty in accounting for the development of complex structures by gradualistic evolution. What Dawkins seems to mean by this assertion is that the step-by-step evolution of complex adaptive systems is a conceptual possibility, not that there is some way to prove that it actually happens. He uses the bat, with its marvelous sonar-like echolocation system that so resembles the product of an advanced technological society, as the paradigm example of how natural selection can explain the development of a complex system that would otherwise be taken as evidence for the existence of a "watchmaker" creator. Dawkins is right to argue that if Darwinist evolution can craft a bat it can make just about anything, but what he neglects to do is to prove that Darwinist evolution can do anything of the kind. It is *conceivable* that bat sonar evolved by some step-by-step process, in which the first hint of an ability to locate by echo was of such value to its possessor that everything else had to follow, but how do we know that such a thing ever happened, or could have happened?

Despite his generally rigid adherence to Darwinist gradualism, even Dawkins finds it impossible to get along without what might be called modest macromutations, meaning mutations that "although they may be large in the magnitude of their effects, turn out not to be large in terms of their complexity." He uses as an example snakes, some contemporary examples of which have more vertebrae than their presumed ancestors. The number of vertebrae has to be

[3] The debate over macromutations has mainly concerned the animal kingdom, but it is known that a special kind of macromutation, known as polyploidy, can produce new plant species. This phenomenon, which involves doubling of chromosome numbers, may occur in two ways: (1) autopolyploidy, which applies only to hermaphrodite species capable of self-fertilization, and (2) allopolyploidy, which may occur as a result of hybridization of two different species. The latter process is thought to have played an important evolutionary role only for plants, although it is not entirely absent from the animal kingdom. In any case, polyploidy would not explain the creation of complex adaptive structures like wings and eyes.

not prove that evolution by micromutation is probable, or even possible. It is likely that Darwinist gradualism is statistically just as unlikely as Goldschmidt's saltationism, once we give adequate attention to all the necessary elements. The advantageous micromutations postulated by neo-Darwinist genetics are tiny, usually too small to be noticed. This premise is important because, in the words of Richard Dawkins, "virtually all the mutations studied in genetics laboratories—which are pretty macro because otherwise geneticists wouldn't notice them—are deleterious to the animals possessing them." But if the necessary mutations are too small to be seen, there will have to be a great many of them (millions?) of the right type coming along when they are needed to carry on the long-term project of producing a complex organ.

The probability of Darwinist evolution depends upon the quantity of favorable micromutations required to create complex organs and organisms, the frequency with which such favorable micromutations occur just where and when they are needed, the efficacy of natural selection in preserving the slight improvements with sufficient consistency to permit the benefits to accumulate, and the time allowed by the fossil record for all this to have happened. Unless we can make calculations taking all these factors into account, we have no way of knowing whether evolution by micromutation is more or less improbable than evolution by macromutation.

Some mathematicians did try to make the calculations, and the result was a rather acrimonious confrontation between themselves and some of the leading Darwinists at the Wistar Institute in Philadelphia in 1967. The report of the exchange is fascinating, not just because of the substance of the mathematical challenge, but even more because of the logic of the Darwinist response. For example, the mathematician D. S. Ulam argued that it was highly improbable that the eye could have evolved by the accumulation of small mutations, because the number of mutations would have to be so large and the time available was not nearly long enough for them to appear. Sir Peter Medawar and C. H. Waddington responded that Ulam was doing his science backwards; the fact was that the eye *had* evolved and therefore the mathematical difficulties must be only apparent. Ernst Mayr observed that Ulam's calculations were based on assumptions that might be unfounded, and concluded that

"Somehow or other by adjusting these figures we will come out all right. We are comforted by the fact that evolution has occurred."

The Darwinists were trying to be reasonable, but it was as if Ulam had presented equations proving that gravity is too weak a force to prevent us all from floating off into space. Darwinism to them was not a theory open to refutation but a fact to be accounted for, at least until the mathematicians could produce an acceptable alternative. The discussion became particularly heated after a French mathematician named Schützenberger concluded that "there is a considerable gap in the neo-Darwinian theory of evolution, and we believe this gap to be of such a nature that it cannot be bridged within the current conception of biology." C. H. Waddington thought he saw where this reasoning was headed, and retorted that "Your argument is simply that life must have come about by special creation." Schützenberger (and anonymous voices from the audience) shouted "No!," but in fact the mathematicians did not present an alternative.

The difficulties with both the micromutational and macromutational theories are so great that we might expect to see some effort being made to come up with a middle ground that minimizes the disadvantages of both extremes. Stephen Jay Gould attempted something of the sort, both in his 1980 scientific paper proposing a "new and general theory," and in his popular article "The Return of the Hopeful Monster." Gould tried to rehabilitate Goldschmidt while domesticating his monster. Goldschmidt did not really mean that "new species arise all at once, fully formed, by a fortunate macromutation," Gould explained, and what he did mean can be reconciled with "the essence of Darwinism."

> Suppose that a discontinuous change in adult form arises from a small genetic alteration. Problems of discordance with other members of the species do not arise, and the large, favorable variant can spread through a population in Darwinian fashion. Suppose also that this large change does not produce a perfected form all at once, but rather serves as a "key" adaptation to shift its possessor toward a new mode of life. Continued success in this new mode may require a large set of collateral alterations, morphological and behavioral; these may arise by a more traditional, gradual route once the key adaptation forces a profound shift in selective pressures.

probably become awkward for climbing or grasping long before they became very useful for gliding, thus placing the hypothetical intermediate creature at a serious disadvantage.

There is a good skeptical discussion of the bird wing problem in chapter 9 of Denton's *Evolution: A Theory in Crisis*. Denton describes the exquisitely functional avian feather, with its interlocking hooks and other intricate features that make it suitable for flight and quite distinct from any form of feather used only for warmth. Bird feathers must have evolved from reptilian scales if Darwinism is true, but once again the intermediates are hard to imagine. Still more difficult a problem is presented by the distinctive avian lung, which is quite different in structure than that of any conceivable evolutionary ancestor. According to Denton,

> Just how such a different respiratory system could have evolved gradually from the standard vertebrate design is fantastically difficult to envisage, especially bearing in mind that the maintenance of respiratory function is absolutely vital to the life of an organism to the extent that the slightest malfunction leads to death within minutes. Just as the feather cannot function as an organ of flight until the hooks and barbules are coadapted to fit together perfectly, so the avian lung cannot function as an organ of respiration until the parabronchi system which permeates it and the air sac system which guarantees the parabronchi their air supply are both highly developed and able to function together in a perfectly integrated manner.

Whether one finds the gradualist scenarios for the development of complex systems plausible involves an element of subjective judgment. It is a matter of objective fact, however, that these scenarios are speculation. Bird and bat wings appear in the fossil record already developed, and no one has ever confirmed by experiment that the gradual evolution of wings and eyes is possible. This absence of historical or experimental confirmation is presumably what Gould had in mind when he wrote that "These tales, in the 'just-so' tradition of evolutionary natural history, do not prove anything." Are we dealing here with science or with rationalist versions of Kipling's fables?

Darwin wrote that "If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down." One particularly eminent scientist of the mid-twentieth century who concluded that it had absolutely broken down was the German-American geneticist, Professor Richard Goldschmidt of the University of California at Berkeley. Goldschmidt issued a famous challenge to the neo-Darwinists, listing a series of complex structures from mammalian hair to hemoglobin that he thought could not have been produced by the accumulation and selection of small mutations. Like Pierre Grassé, Goldschmidt concluded that Darwinian evolution could account for no more than variations within the species boundary; unlike Grassé, he thought that evolution beyond that point must have occurred in single jumps through macromutations. He conceded that large-scale mutations would in almost all cases produce hopelessly maladapted monsters, but he thought that on rare occasions a lucky accident might produce a "hopeful monster," a member of a new species with the capacity to survive and propagate (but with what mate?).

The Darwinists met this fantastic suggestion with savage ridicule. As Goldschmidt put it, "This time I was not only crazy but almost a criminal." Gould has even compared the treatment accorded Goldschmidt in Darwinist circles with the daily "Two Minute Hate" directed at "Emmanuel Goldstein, enemy of the people" in George Orwell's novel *1984*. The venom is explained by the emotional attachment Darwinists have to their theory, but the ridicule had a sound scientific basis. If Goldschmidt really meant that all the complex interrelated parts of an animal could be reformed together in a single generation by a systemic macromutation, he was postulating a virtual miracle that had no basis either in genetic theory or in experimental evidence. Mutations are thought to stem from random errors in copying the commands of the DNA's genetic code. To suppose that such a random event could reconstruct even a single complex organ like a liver or kidney is about as reasonable as to suppose that an improved watch can be designed by throwing an old one against a wall. Adaptive macromutations are impossible, say the Darwinists, especially if required in any quantity, and so all those complex organs must have evolved—many times independently—by the selective accumulation of micromutations over a long period of time.

But now we must deal with another fallacy, and a supremely important one. That evolution by macromutation is impossible does

dence of the many transitional forms that Darwin's theory required to have existed. Darwin made the obvious response, arguing that the evidence was lacking because the fossil record was incomplete. This was a reasonable possibility at the time, and conveniently safe from disproof; we shall return to it in the next chapter.

The more pressing difficulty was theoretical. Many organs require an intricate combination of complex parts to perform their functions. The eye and the wing are the most common illustrations, but it would be misleading to give the impression that either is a special case; human and animal bodies are literally packed with similar marvels. How can such things be built up by "infinitesimally small inherited variations, *each* profitable to the preserved being?" The first step towards a new function—such as vision or ability to fly—would not necessarily provide any advantage unless the other parts required for the function appeared at the same time. As an analogy, imagine a medieval alchemist producing by chance a silicon microchip; in the absence of a supporting computer technology the prodigious invention would be useless and he would throw it away.

Stephen Jay Gould asked himself "the excellent question, What good is 5 per cent of an eye?," and speculated that the first eye parts might have been useful for something other than sight. Richard Dawkins responded that

> An ancient animal with 5 per cent of an eye might indeed have used it for something other than sight, but it seems to me as likely that it used it for 5 per cent vision. And actually I don't think it is an excellent question. Vision that is 5 per cent as good as yours or mine is very much worth having in comparison with no vision at all. So is 1 per cent vision better than total blindness. And 6 per cent is better than 5, 7 per cent better than 6, and so on up the gradual, continuous series.

The fallacy in that argument is that "5 per cent of an eye" is not the same thing as "5 per cent of normal vision." For an animal to have any useful vision at all, many complex parts must be working together. Even a complete eye is useless unless it belongs to a creature with the mental and neural capacity to make use of the information by doing something that furthers survival or reproduction.

What we have to imagine is a chance mutation that provides this complex capacity all at once, at a level of utility sufficient to give the creature an advantage in producing offspring.

Dawkins went on to restate Darwin's answer to the eye conundrum, pointing out that there is a plausible series of intermediate eye-designs among living animals. Some single-celled animals have a light-sensitive spot with a little pigment screen behind it, and in some many-celled animals a similar arrangement is set in a cup, which gives improved direction-finding capability. The ancient nautilus has a pinhole eye with no lens, the squid's eye adds the lens, and so on. None of these different types of eyes are thought to have evolved from any of the others, however, because they involve different types of structures rather than a series of similar structures growing in complexity.

If the eye evolved at all, it evolved many times. Ernst Mayr writes that the eye must have evolved independently at least 40 times, a circumstance which suggests to him that "a highly complicated organ can evolve repeatedly and convergently when advantageous, provided such evolution is at all probable." But then why did the many primitive eye forms that are still with us never evolve into more advanced forms? Dawkins admits to being baffled by the nautilus, which in its hundreds of millions of years of existence has never evolved a lens for its eye despite having a retina that is "practically crying out for (this) particular simple change."[1]

The wing, which exists in quite distinct forms in insects, birds, and bats, is the other most frequently cited puzzle. Would the first "infinitesimally small inherited modification" in the direction of wing construction confer a selective advantage? Dawkins thinks that it would, because even a small flap or web might help a small creature to jump farther, or save it from breaking its neck in a fall. Eventually such a proto-wing might develop to a point where the creature would begin gliding, and by further gradual improvements it would become capable of genuine flight. What this imaginative scenario neglects is that forelimbs evolving into wings would

[1] Before leaving the subject of the eye, I should add that Darwinists cite *imperfections* in the eye as evidence that it was not designed by an omniscient creator. According to Dawkins, the photocells are "wired backwards," and "any tidy-minded engineer" would not have been so sloppy.

Chapter Three

Mutations Great and Small

"EVOLUTION" IS A concept broad enough to encompass just about any alternative to instantaneous creation, and so it is not surprising that thinkers have speculated about evolution ever since ancient times. Charles Darwin's unique contribution was to describe a plausible mechanism by which the necessary transformations could occur, a mechanism that did not require divine guidance, mysterious vital forces, or any other causes not presently operating in the world. Darwin was particularly anxious to avoid the need for any "saltations"—sudden leaps by which a new type of organism appears in a single generation. Saltations (or systemic macromutations, as they are often called today) are believed to be theoretically impossible by most scientists, and for good reason. Living creatures are extremely intricate assemblies of interrelated parts, and the parts themselves are also complex. It is impossible to imagine how the parts could change in unison as a result of chance mutation.

In a word (Darwin's word), a saltation is equivalent to a miracle. At

the extreme, saltationism is virtually indistinguishable from special creation. If a snake's egg were to hatch and a mouse emerge, we could with equal justice classify the event as an instance of evolution or creation. Even the sudden appearance of a single complex organ, like an eye or wing, would imply supernatural intervention. Darwin emphatically rejected any evolutionary theory of this sort, writing to Charles Lyell that

> If I were convinced that I required such additions to the theory of natural selection, I would reject it as rubbish. . . . I would give nothing for the theory of natural selection, if it requires miraculous additions at any one stage of descent.

Darwin aimed to do for biology what Lyell had done for geology: explain great changes on uniformitarian and naturalistic principles, meaning the gradual operation over long periods of time of familiar natural forces that we can still see operating in the present. He understood that the distinctive feature of his theory was its uncompromising philosophical materialism, which made it truly scientific in the sense that it did not invoke any mystical or supernatural forces that are inaccessible to scientific investigation. To achieve a fully materialistic theory Darwin had to explain every complex characteristic or major transformation as the cumulative product of a great many tiny steps. In his own eloquent words:

> Natural selection can act only by the preservation and accumulation of infinitesimally small inherited modifications, each profitable to the preserved being; and as modern geology has almost banished such views as the excavation of a great valley by a single diluvial wave, so will natural selection, if it be a true principle, banish the belief of the continued creation of new organic beings, or of any great and sudden modification in their structure.

T. H. Huxley protested against this dogmatic gradualism from the start, warning Darwin in a famous letter that "You have loaded yourself with an unnecessary difficulty in adopting *natura non facit saltum* so unreservedly." The difficulty was hardly unnecessary, given Darwin's purpose, but it was real enough. In the long term the biggest problem was the fossil record, which did not provide evi-

characteristic is likely to change other features as well, and whether or not it is advantageous depends upon the net effect. Characteristics which on their face appear to be maladaptive may therefore be presumed to be linked genetically to more favorable characteristics, and natural selection can be credited with preserving the package.

I am not implying that there is anything inherently unreasonable in invoking pleiotropy, or kinship selection, or developmental constraints to explain why apparent anomalies are not necessarily inconsistent with Darwinism. If we assume that Darwinism is basically true then it is perfectly reasonable to adjust the theory as necessary to make it conform to the observed facts. The problem is that the adjusting devices are so flexible that in combination they make it difficult to conceive of a way to test the claims of Darwinism empirically. Apparently maladaptive features can be attributed to pleiotropy, or to our inability to perceive the advantage that may be there, or when all else fails simply to "chance." Darwin wrote that "If it could be proved that any part of the structure of any one species had been formed for the exclusive good of another species, it would annihilate my theory, for such could not have been produced through natural selection." But this was the same Darwin who insisted that he had never claimed that natural selection was the exclusive mechanism of evolution.

One important subsidiary concept—sexual selection—illustrates the skill of Darwinists at incorporating recalcitrant examples into their theory. Sexual selection is a relatively minor component in Darwinist theory today, but to Darwin it was almost as important as natural selection itself. (Darwin's second classic, *The Descent of Man*, is mainly a treatise on sexual selection.) The most famous example of sexual selection is the peacock's gaudy fan, which is obviously an encumbrance when a peacock wants to escape a predator. The fan is stimulating to peahens, however, and so its possession increases the peacock's prospects for producing progeny even though it decreases his life expectancy.

The explanation so far is reasonable, even delightful, but what I find intriguing is that Darwinists are not troubled by the unfitness of the peahen's sexual taste. Why would natural selection, which supposedly formed all birds from lowly predecessors, produce a species whose females lust for males with life-threatening decorations? The peahen ought to have developed a preference for males

with sharp talons and mighty wings. Perhaps the taste for fans is associated genetically with some absolutely vital trait like strong egg shells, but then why and how did natural selection encourage such an absurd genetic linkage? Nevertheless, Douglas Futuyma boldly proclaims the peacock as a problem not for Darwinists but for creationists:

> Do the creation scientists really suppose their Creator saw fit to create a bird that couldn't reproduce without six feet of bulky feathers that make it easy prey for leopards?

I don't know what creation-scientists may suppose, but it seems to me that the peacock and peahen are just the kind of creatures a whimsical Creator might favor, but that an "uncaring mechanical process" like natural selection would never permit to develop.

What we are seeing in Futuyma's comment about the peacock is the debating principle that the best defense is a good offense, but we are also seeing the influence of philosophical preconception in blinding an intelligent Darwinist to the existence of a counterexample. Julian Huxley once wrote that "Improbability is to be *expected* as a result of natural selection; and we have the paradox that an exceedingly high apparent improbability in its products can be taken as evidence for the high degree of its efficacy." On that basis the theory has nothing to fear from the evidence.

Natural selection is the most famous element in Darwinism, but it is not necessarily the most important element. Selection merely preserves or destroys something that already exists. Mutation has to provide the favorable innovations before natural selection can retain and encourage them. That brings us to our next subject, which requires a separate chapter.

experiment also knows that it has nothing to do with the origin of any species, or even any variety, because dark and white moths were present throughout the experiment. Only the ratios of one variety to the other changed. How could intelligent people have been so gullible as to imagine that the Kettlewell experiment in any way supported the ambitious claims of Darwinism? To answer that question we need to consider a fourth way in which natural selection can be formulated.

Natural Selection as a Philosophical Necessity

The National Academy of Sciences told the Supreme Court that the most basic characteristic of science is "reliance upon naturalistic explanations," as opposed to "supernatural means inaccessible to human understanding." In the latter, unacceptable category contemporary scientists place not only God, but also any non-material vital force that supposedly drives evolution in the direction of greater complexity, consciousness, or whatever. If science is to have any explanation for biological complexity at all it has to make do with what is left when the unacceptable has been excluded. Natural selection is the best of the remaining alternatives, probably the only alternative.

In this situation some may decide that Darwinism simply *must* be true, and for such persons the purpose of any further investigation will be merely to explain how natural selection works and to solve the mysteries created by apparent anomalies. For them there is no need to test the theory itself, for there is no respectable alternative to test it against. Any persons who say the theory itself is inadequately supported can be vanquished by the question "Darwin's Bulldog" T. H. Huxley used to ask the doubters in Darwin's time: What is your alternative?

I do not think that many scientists would be comfortable accepting Darwinism solely as a philosophical principle, without seeking to find at least some empirical evidence that it is true. But there is an important difference between going to the empirical evidence to test a doubtful theory against some plausible alternative, and going to the evidence to look for confirmation of the only theory that one is willing to tolerate. We have already seen that distinguished scientists have accepted uncritically the questionable analogy between

natural and artificial selection, and that they have often been undisturbed by the fallacies of the "tautology" and "deductive logic" formulations. Such illogic survived and reproduced itself for the same reason that an apparently incompetent species sometimes avoids extinction; there was no effective competition in its ecological niche.

If positive confirmation of the creative potency of natural selection is not required, there is little danger that the theory will be disproved by negative evidence. Darwinists have evolved an array of subsidiary concepts capable of furnishing a plausible explanation for just about any conceivable eventuality. For example, the living fossils, which have remained basically unchanged for millions of years while their cousins were supposedly evolving into more advanced creatures like human beings, are no embarrassment to Darwinists. They failed to evolve because the necessary mutations didn't arrive, or because of "developmental constraints," or because they were already adequately adapted to their environment. In short, they didn't evolve because they didn't evolve.

Some animals give warning signals at the approach of predators, apparently reducing their own safety for the benefit of others in the herd. How does natural selection encourage the evolution of a trait for self-sacrifice? Some Darwinists attribute the apparent anomaly to "group selection." Human nations benefit if they contain individuals willing to die in battle for their country, and likewise animal groups containing self-sacrificing individuals may have an advantage over groups composed exclusively of selfish individuals.

Other Darwinists are scornful of group selection and prefer to explain altruism on the basis of "kinship selection." By sacrificing itself to preserve its offspring or near relations an individual promotes the survival of its genes. Selection may thus operate at the genetic level to encourage the perpetuation of genetic combinations that produce individuals capable of altruistic behavior. By moving the focus of selection either up (to the group level) or down (to the genetic level), Darwinists can easily account for traits that seem to contradict the selection hypothesis at the level of individual organisms.

Potentially the most powerful explanatory tool in the entire Darwinist armory is *pleiotropy*, the fact that a single gene has multiple effects. This means that any mutation which affects one functional

4. The allele (genetic state) responsible for sickle-cell anemia in African populations is also associated with a trait that confers resistance to malaria. Individuals who are totally free of the sickle-cell allele suffer high mortality from malaria, and individuals who inherit the sickle-cell allele from both parents tend to die early from anemia. Chances for survival are greatest when the individual inherits the sickle-cell allele from one parent but not the other, and so the trait is not bred out of the population. Futuyma comments that the example shows not only that natural selection is effective, but also that it is "an uncaring mechanical process."

5. Mice populations have been observed to cease reproducing and become extinct when they are temporarily "flooded" by the spread of a gene which causes sterility in the males.

6. Finally, Futuyma summarizes Kettlewell's famous observations of "industrial melanism" in the peppered moth. When trees were darkened by industrial smoke, dark-colored (melanic) moths became abundant because predators had difficulty seeing them against the trees. When the trees became lighter due to reduced air pollution, the lighter-colored moths had the advantage. Kettlewell's observations showed in detail how the prevailing color of moths changed along with the prevailing color of the trees. Subsequent commentators have observed that the example shows stability as well as cyclical change within a boundary, because the ability of the species to survive in a changing environment is enhanced if it maintains at all times a supply of both light and dark moths. If the light variety had disappeared altogether during the years of dark trees, the species would have been threatened with extinction when the trees lightened.

There are a few other examples in Futuyma's chapter, but I believe they are meant as illustrations to show how Darwinism accounts for certain anomalies like self-sacrificing behavior and the peacock's fan rather than as additional examples of observations confirming the effect of natural selection in producing change. If we take these six examples as the best available observational evidence of natural selection, we can draw two conclusions:

1. There is no reason to doubt that peculiar circumstances can sometimes favor drug-resistant bacteria, or large birds as opposed

to small ones, or dark-colored moths as opposed to light-colored ones. In such circumstances the population of drug-susceptible bacteria, small birds, and light-colored moths may become reduced for some period of time, or as long as the circumstances prevail.

2. None of the "proofs" provides any persuasive reason for believing that natural selection can produce new species, new organs, or other major changes, or even minor changes that are permanent. The sickle-cell anemia case, for example, merely shows that in special circumstances an apparently disadvantageous trait may not be eliminated from the population. That larger birds have an advantage over smaller birds in high winds or droughts has no tendency whatever to prove that similar factors caused birds to come into existence in the first place. Very likely smaller birds have the advantage in other circumstances, which explains why birds are not continually becoming larger.

Pierre Grassé was as unimpressed by this kind of evidence as I am, and he summarized his conclusions at the end of his chapter on evolution and natural selection:

> The "evolution in action" of J. Huxley and other biologists is simply the observation of demographic facts, local fluctuations of genotypes, geographical distributions. Often the species concerned have remained practically unchanged for hundreds of centuries! Fluctuation as a result of circumstances, with prior modification of the genome, does not imply evolution, and we have tangible proof of this in many panchronic species [i.e. living fossils that remain unchanged for millions of years]. . . .

This conclusion seems so obviously correct that it gives rise to another problem. Why do other people, including experts whose intelligence and intellectual integrity I respect, think that evidence of local population fluctuations confirms the hypothesis that natural selection has the capacity to work engineering marvels, to construct wonders like the eye and the wing? Everyone who studies evolution knows that Kettlewell's peppered moth experiment is the classic demonstration of the power of natural selection, and that Darwinists had to wait almost a century to see even this modest confirmation of their central doctrine. Everyone who studies the

the absence of change. There are numerous "living fossils" which are much the same today as they were millions of years ago, at least as far as we can determine.

Patterson is not the only evolutionist who thinks of natural selection as a matter of deductive logic, although most who have used this formulation have thought more highly of the theory than he appears to do. For example, origin of life researcher A. G. Cairns-Smith employed the syllogistic formulation (substantially as Darwin himself stated it) to explain how complex organisms can evolve from very simple ones:

> Darwin persuades us that the seemingly purposeful construction of living things can very often, and perhaps always, be attributed to the operation of natural selection. If you have things that are reproducing their kind; *if* there are sometimes random variations, nevertheless, in the offspring; *if* such variations can be inherited; *if* some such variations can sometimes confer an advantage on their owners; *if* there is competition between the reproducing entities;—*if* there is an overproduction so that not all will be able to produce offspring themselves—then these entities will get better at reproducing their kind. Nature acts as a selective breeder in these circumstances: the stock cannot help but improve.

In fact the stock is often highly successful at resisting improvement, often for millions of years, so there must be something wrong with the logic. This time it is the confusion generated by that word "advantage." Advantage in the proper Darwinist sense, as George Gaylord Simpson explained for us, does not mean improvement as humans measure it. Ants and bacteria are just as advantaged as we are, judged by the exclusive criterion of success in reproduction. In any population some individuals will leave more offspring than others, even if the population is not changing or is headed straight for extinction.

Natural Selection as a Scientific Hypothesis

Up to this point we have been disposing of some simple fallacies to clear the field of distractions, but now we get to the important category which deserves our most respectful scrutiny. I am sure that today most evolutionary scientists would insist that Darwinistic natural selection is a scientific hypothesis which has been so thoroughly tested and confirmed by the evidence that it should be accepted by reasonable persons as a presumptively adequate explanation for the evolution of complex life forms. The hypothesis, to be precise, is that natural selection (in combination with mutation) is an innovative evolutionary process capable of producing new kinds of organs and organisms. That brings us to the critical question: what evidence confirms that this hypothesis is true?

Douglas Futuyma has done the best job of marshalling the supporting evidence, and here are the examples he gives of observations that confirm the creative effectiveness of natural selection:

1. Bacteria naturally develop resistance to antibiotics, and insect pests become resistant to insecticides, because of the differential survival of mutant forms possessing the advantage of resistance.

2. In 1898 a severe storm in Massachusetts left hundreds of dead and dying birds in its wake. Someone brought 136 exhausted sparrows to a scientist named Bumpus, I imagine so they could be cared for, but Bumpus was made of sterner stuff and killed the survivors to measure their skeletons. He found that among male sparrows the larger birds had survived more frequently than the smaller ones, even though the size differential was relatively slight.

3. A drought in the Galapagos Islands in 1977 caused a shortage of the small seeds on which finches feed. As a consequence these birds had to eat larger seeds, which they usually ignore. After one generation there had been so much mortality among the smaller finches, who could not easily eat the larger seeds, that the average size of the birds (and especially their beaks) went up appreciably. Futuyma comments: "Very possibly the birds will evolve back to their previous state if the environment goes back to normal,[3] but we can see in this example what would happen if the birds were forced to live in a consistently dry environment: they would evolve a permanent adaptation to whatever kinds of seeds are consistently available. This is natural selection in action, and it is not a matter of chance."

[3] In fact this is exactly what happened. The article "Oscillating Selection on Darwin's Finches" by Gibbs and Grant [*Nature*, vol. 327, p. 511, 1987] reports that small adults survived much better than large ones following the wet year 1982-83, completely reversing the trend of 1977-82.

> Darwin's major contribution was, of course, the suggestion that evolution can be explained by the natural selection of random variations. Natural selection, which was at first considered as though it were a hypothesis that was in need of experimental or observational confirmation, turns out on closer inspection to be a tautology, a statement of an inevitable but previously unrecognized relation. It states that the fittest individuals in a population (defined as those which leave most offspring) will leave most offspring. This fact in no way reduces the magnitude of Darwin's achievement; only after it was clearly formulated, could biologists realize the enormous power of the principle as a weapon of explanation.

That was not an offhand statement, but a considered judgment published in a paper presented at the great convocation at the University of Chicago in 1959 celebrating the hundredth anniversary of the publication of *The Origin of Species*. Apparently, none of the distinguished authorities present told Waddington that a tautology does not explain anything. When I want to know how a fish can become a man, I am not enlightened by being told that the organisms that leave the most offspring are the ones that leave the most offspring.

It is not difficult to understand how leading Darwinists were led to formulate natural selection as a tautology. The contemporary neo-Darwinian synthesis grew out of population genetics, a field anchored in mathematics and concerned with demonstrating how rapidly very small mutational advantages could spread in a population. The advantages in question were assumptions in a theorem, not qualities observed in nature, and the mathematicians naturally tended to think of them as "whatever it was that caused the organism and its descendants to produce more offspring than other members of the species." This way of thinking spread to the zoologists and paleontologists, who found it convenient to assume that their guiding theory was simply true by definition. As long as outside critics were not paying attention, the absurdity of the tautology formulation was in no danger of exposure.

What happened to change this situation is that Popper's comment received a great deal of publicity, and creationists and other unfriendly critics began citing it to support their contention that Darwinism is not really a scientific theory. The Darwinists themselves became aware of a dangerous situation, and thereafter critics raising the tautology claim were firmly told that they were simply demonstrating their inability to understand Darwinism. As we shall see in later chapters, however, in practice natural selection continues to be employed in its tautological formulation.

If the concept of natural selection were really only a tautology I could end the chapter at this point, because a piece of empty repetition obviously does not have the power to guide an evolutionary process in its long journey from the first replicating macromolecule to modern human beings. But although natural selection can be formulated as a tautology, and often has been, it can also be formulated in other ways that are not so easily dismissed. We must go on to consider these other possibilities.

Natural Selection as a Deductive Argument

Visitors to the British Natural History Museum will find prominently on sale the museum's handbook on evolution, written by paleontologist Colin Patterson. When he considers the scientific status of Darwinism, Patterson writes that the theory can be presented in the form of a deductive argument, for example:

1. All organisms must reproduce;
2. All organisms exhibit hereditary variations;
3. Hereditary variations differ in their effect on reproduction;
4. Therefore variations with favorable effects on reproduction will succeed, those with unfavorable effects will fail, and organisms will change.

Patterson observes that the theorem establishes only that some natural selection will occur, not that it is a general explanation for evolution. Actually, the theorem does not even establish that organisms will change. The range of hereditary variations may be narrow, and the variations which survive may be just favorable enough to keep the species as it is. Possibly the species would change a great deal more (in the direction of eventual extinction) if the least favored individuals most often succeeded in reproducing their kind. That the effect of natural selection may be to keep a species from changing is not merely a theoretical possibility. As we shall see in Chapter Four, the prevailing characteristic of fossil species is *stasis*—

with each other but not with other dogs, they would still have made only the tiniest step towards proving Darwinism's important claims.

That the analogy to artificial selection is defective does not necessarily mean that Darwin's theory is wrong, but it does mean that we will have to look for more direct evidence to see if natural selection really does have a creative effect. *Before* looking at what the Darwinists have been able to come up with, however, we need to ask whether evidence is even necessary. Strange as it may seem, there are many statements in the Darwinist literature to the effect that the validity of the theory can be demonstrated simply as a matter of logic.

Natural Selection as a Tautology

Many of the most prominent neo-Darwinists have written at one time or another that natural selection is a tautology, a way of saying the same thing twice. In this formulation the theory predicts that the fittest organisms will produce the most offspring, and it defines the fittest organisms as the ones which produce the most offspring. It is important to document this point, because many Darwinists have convinced themselves that the tautology idea is a misunderstanding introduced into the literature by creationists and other uncomprehending faultfinders. But here are a few examples collected by Norman Macbeth:

> J. B. S. Haldane (1935): " . . . the phrase, 'survival of the fittest,' is something of a tautology. So are most mathematical theorems. There is no harm in saying the same truth in two different ways."
>
> Ernst Mayr (1963): " . . . those individuals that have the most offspring are by definition . . . the fittest ones."
>
> George Gaylord Simpson (1964): "Natural selection favors fitness only if you define fitness as leaving more descendants. In fact geneticists do define it that way, which may be confusing to others. To a geneticist fitness has nothing to do with health, strength, good looks, or anything but effectiveness in breeding."

The explanation by Simpson just quoted indicates why it is not easy to formulate the theory of natural selection other than as a tautology. It may seem obvious, for example, that it is advantageous

for a wild stallion to be able to run faster, but in the Darwinian sense this will be true only to the extent that a faster stallion sires more offspring. If greater speed leads to more frequent falls, or if faster stallions tend to outdistance the mares and miss opportunities for reproduction, then the improvement may be disadvantageous.

Just about any characteristic can be either advantageous or disadvantageous, depending upon the surrounding environmental conditions. Does it seem that the ability to fly is obviously an advantage? Darwin hypothesized that natural selection might have caused beetles on Madeira to lose the ability to fly, because beetles capable of flight tended to be blown out to sea. The large human brain requires a large skull which causes discomfort and danger to the mother in childbirth. We assume that our brain size is advantageous because civilized humans dominate the planet, but it is far from obvious that the large brain was a net advantage in the circumstances in which it supposedly evolved. Among primates in general, those with the largest brains are not the ones least in danger of extinction.

In all such cases we can presume a characteristic to be advantageous because a species which has it seems to be thriving, but in most cases it is impossible to identify the advantage independently of the outcome. That is why Simpson was so insistent that "advantage" has no inherent meaning other than actual success in reproduction. All we can say is that the individuals which produced the most offspring must have had the qualities required for producing the most offspring.

The famous philosopher of science Karl Popper at one time wrote that Darwinism is not really a scientific theory because natural selection is an all-purpose explanation which can account for anything, and which therefore explains nothing. Popper backed away from this position after he was besieged by indignant Darwinist protests, but he had plenty of justification for taking it. As he wrote in his own defense, "some of the greatest contemporary Darwinists themselves formulate the theory in such a way that it amounts to the tautology that those organisms that leave most offspring leave most offspring," citing Fisher, Haldane, Simpson, "and others." One of the others was C. H. Waddington, whose attempt to make sense of the matter deserves to be preserved for posterity:

That he made that point by citing the accomplishments of intelligent designers proves only that the receptive audience for his theory was highly uncritical.

Artificial selection is not basically the same sort of thing as natural selection, but rather is something fundamentally different. Human breeders produce variations among sheep or pigeons for purposes absent in nature, including sheer delight in seeing how much variation can be achieved. If the breeders were interested only in having animals capable of surviving in the wild, the extremes of variation would not exist. When domesticated animals return to the wild state, the most highly specialized breeds quickly perish and the survivors revert to the original wild type. Natural selection is a conservative force that prevents the appearance of the extremes of variation that human breeders like to encourage.

What artificial selection actually shows is that there are definite limits to the amount of variation that even the most highly skilled breeders can achieve. Breeding of domestic animals has produced no new species, in the commonly accepted sense of new breeding communities that are infertile when crossed with the parent group. For example, all dogs form a single species because they are chemically capable of interbreeding, although inequality of size in some cases makes natural copulation impracticable. The eminent French zoologist Pierre Grassé concluded that the results of artificial selection provide powerful testimony against Darwin's theory:

> In spite of the intense pressure generated by artificial selection (eliminating any parent not answering the criteria of choice) over whole millennia, no new species are born. A comparative study of sera, hemoglobins, blood proteins, interfertility, etc., proves that the strains remain within the same specific definition. This is not a matter of opinion or subjective classification, but a measurable reality. The fact is that selection gives tangible form to and gathers together all the varieties a genome is capable of producing, but does not constitute an innovative evolutionary process.

In other words, the reason that dogs don't become as big as elephants, much less change into elephants, is not that we just haven't been breeding them long enough. Dogs do not have the genetic capacity for that degree of change, and they stop getting bigger when the genetic limit is reached.

Darwinists disagree with that judgment, and they have some points to make. They point with pride to experiments with laboratory fruitflies. These have not produced anything but fruitflies, but they have produced changes in a multitude of characteristics. Plant hybrids have been developed which can breed with each other, but not with the parent species, and which therefore meet the accepted standard for new species. With respect to animals, Darwinists attribute the inability to produce new species to a lack of sufficient time. Humans have been breeding dogs for only a few thousand years, but nature has millions and even hundreds of millions of years at her disposal. In some cases, convincing circumstantial evidence exists of evolution that has produced new species in nature. Familiar examples include the hundreds of fruitfly species in Hawaii and the famous variations among "Darwin's Finches" on the Galapagos Islands.

The time available unquestionably has to be taken into account in evaluating the results of breeding experiments, but it is also possible that the greater time available to nature may be more than counterbalanced by the power of intelligent purpose which is brought to bear in artificial selection. With respect to the famous fruitfly experiments, for example, Grassé noted that "The fruitfly (*drosophila melanogaster*) the favorite pet insect of the geneticists, whose geographical, biotropical, urban, and rural genotypes are now known inside out, seems not to have changed since the remotest times." Nature has had plenty of time, but it just hasn't been doing what the experimenters have been doing.

Lack of time would be a reasonable excuse if there were no other known factor limiting the change that can be produced by selection, but in fact selective change is limited by the inherent variability in the gene pool. After a number of generations the capacity for variation runs out. It might conceivably be renewed by mutation, but whether (and how often) this happens is not known.

Whether selection has ever accomplished speciation (i.e. the production of a new species) is not the point. A biological species is simply a group capable of interbreeding. Success in dividing a fruitfly population into two or more separate populations that cannot interbreed would not constitute evidence that a similar process could in time produce a fruitfly from a bacterium. If breeders one day did succeed in producing a group of dogs that can reproduce

meant that new species have appeared during the long course of the earth's history by a natural process he called "descent with modification." The second proposition was that this evolutionary process can be extended to account for all or nearly all the diversity of life, because all living things descended from a very small number of common ancestors, perhaps a single microscopic ancestor. The third proposition, and the one most distinctive to Darwinism, was that this vast process was guided by natural selection or "survival of the fittest," a guiding force so effective that it could accomplish prodigies of biological craftsmanship that people in previous times had thought to require the guiding hand of a creator.[1] The evidence for this third proposition is the subject of this chapter.

The question is *not* whether natural selection occurs. Of course it does, and it has an effect in maintaining the genetic fitness of a population. Infants with severe birth defects do not survive to maturity without expensive medical care, and creatures which do not survive to reproduce do not leave descendants. These effects are unquestioned, but Darwinism asserts a great deal more than merely that species avoid genetic deterioration due to natural attrition among the genetically unfit. Darwinists claim that this same force of attrition has a building effect so powerful that it can begin with a bacterial cell and gradually craft its descendants over billions of years to produce such wonders as trees, flowers, ants, birds, and humans. How do we know that all this is possible?

Darwinian evolution postulates two elements. The first is what Darwin called "variation," and what scientists today call *mutation.*[2]

[1] Darwin did not insist that all evolution was by natural selection, nor do his successors. He wrote at the end of the introduction to the first (1859) edition of *The Origin of Species* that "I am convinced that natural selection has been the main but not the exclusive means of modification" and later complained of the "steady misrepresentation" that had ignored this qualification. On the other hand, Darwin was vague about the importance of the alternatives, one of which was "variations which seem to us in our ignorance to arise spontaneously." Contemporary neo-Darwinists also practice a tactically advantageous flexibility concerning the frequency and importance of non-selective evolution. Stephen Jay Gould wrote that this imprecision "imposes a great frustration upon anyone who would characterize the modern synthesis in order to criticize it," and I am sure that every critic shares the frustration. Readers should therefore beware of taking at face value claims by neo-Darwinist authorities that some critic has misunderstood or mischaracterized their theory.

[2] "Mutation" as used here is a simple label for the set of mechanisms which provide the genetic variation upon which natural selection can go to work. The set includes point mutations, chromosomal doubling, gene duplication, and recombination. The essential point is that the variations are supposed to be *random.* Creative evolution would be much easier to envisage if some guiding force caused the right mutations to arrive on schedule. Orthodox genetic theory insists that no such guiding principle for mutation exists, so creatures have to make do with whatever blind nature happens to provide.

Mutations are randomly occurring genetic changes which are nearly always harmful when they produce effects in the organism large enough to be visible, but which may occasionally slightly improve the organism's ability to survive and reproduce. Organisms generally produce more offspring than can survive to maturity, and offspring that possess an advantage of this kind can be expected to produce more descendants themselves, other things being equal, than less advantaged members of the species. As the process of differential survival continues, the trait eventually spreads throughout the species, and it may become the basis for further cumulative improvements in succeeding generations. Given enough time, and sufficient mutations of the right sort, enormously complex organs and patterns of adaptive behavior can eventually be produced in tiny cumulative steps, without the assistance of any pre-existing intelligence.

That is, all this can happen if the theory is true. Darwin could not point to impressive examples of natural selection in action, and so he had to rely heavily on an argument by analogy. In the words of Douglas Futuyma:

> When Darwin wrote *The Origin of Species,* he could offer no good cases of natural selection because no one had looked for them. He drew instead an analogy with the artificial selection that animal and plant breeders use to improve domesticated varieties of animals and plants. By breeding only from the woolliest sheep, the most fertile chickens, and so on, breeders have been spectacularly successful in altering almost every imaginable characteristic of our domesticated animals and plants to the point where most of them differ from their wild ancestors far more than related species differ from them.

The analogy to artificial selection is misleading. Plant and animal breeders employ intelligence and specialized knowledge to select breeding stock and to protect their charges from natural dangers. The point of Darwin's theory, however, was to establish that purposeless natural processes can substitute for intelligent design.

readers can understand the essential evidence. But evidence never speaks for itself; it has meaning only in the context of rules of reasoning which determine what may be considered and what counts as evidence. Those rules of reasoning are what I particularly want to examine.

The last subject I should address before beginning is my personal religious outlook, because readers are bound to wonder and because I do not exempt myself from the general rule that bias must be acknowledged and examined. I am a philosophical theist and a Christian. I believe that a God exists who could create out of nothing if He wanted to do so, but who might have chosen to work through a natural evolutionary process instead. I am not a defender of creation-science, and in fact I am not concerned in this book with addressing any conflicts between the Biblical accounts and the scientific evidence.

My purpose is to examine the scientific evidence on its own terms, being careful to distinguish the evidence itself from any religious or philosophical bias that might distort our interpretation of that evidence. I assume that the creation-scientists are biased by their precommitment to Biblical fundamentalism, and I will have very little to say about their position. The question I want to investigate is whether Darwinism is based upon a fair assessment of the scientific evidence, or whether it is another kind of fundamentalism.

Do we really know for certain that there exists some natural process by which human beings and all other living beings could have evolved from microbial ancestors, and eventually from nonliving matter? When the National Academy of Sciences tells us that reliance upon naturalistic explanations is the most basic characteristic of science, is it implying that scientists somehow know that a Creator played no part in the creation of the world and its forms of life? Can something be non-science but true, or does non-science mean non*sense*? Given the emphatic endorsement of naturalistic evolution by the scientific community, can outsiders even contemplate the possibility that this officially established doctrine might be false? Well, come along and let us see.

Chapter Two

Natural Selection

THE STORY OF Charles Darwin has been told many times, and no wonder. The relationship with the lawyer-geologist Charles Lyell, the long voyage in the Beagle with the temperamental Captain Fitzroy, the observations and adventures in South America and the Galapagos Islands, the long years of preparation and delay, the eventual rushed publication of *The Origin of Species* when Alfred Russell Wallace appeared about to publish a similar theory, the controversies and the smashing triumph—all these make a great saga which is always worth another retelling. My subject is not history but the logic of current controversy, however, and so my interest must be in Darwinism and not Darwin. I am also uninterested in the differences between the theory as Darwin originally proposed it and as it is understood by neo-Darwinists today, who have the advantage of the greater understanding of genetics that science has achieved since Darwin's time. My purpose is to explain what concepts the contemporary theory employs, what significant statements about the natural world it makes, and what points of legitimate controversy there may be.

Darwin's classic book argued three important related propositions. The first was that "the species are not immutable." By this he