

was proclaimed by Dobzhansky and other neo-Darwinists. We have to imagine what Steven Stanley calls "rapid branching," a euphemism for mysterious leaps, which somehow produced the human mind and spirit from animal materials. Absent confirmation that such a thing is possible, it is reasonable to keep open the possibility that the putative hominid species were something other than human ancestors, even if the fossil descriptions are reliable.

The hominids, like the mammal-like reptiles, provide at most some plausible candidates for identification as ancestors, if we assume in advance that ancestors must have existed. That 130 years of very determined efforts to confirm Darwinism have done no better than to find a few ambiguous supporting examples is significant negative evidence. It is also significant that so much of the claimed support comes from the human evolution story, where subjectivity in evaluation is most to be expected.

The fossils provide much more discouragement than support for Darwinism when they are examined objectively, but objective examination has rarely been the object of Darwinist paleontology. The Darwinist approach has consistently been to find some supporting fossil evidence, claim it as proof for "evolution," and then ignore all the difficulties. The practice is illustrated by the use that has been made of a newly-discovered fossil of a whale-like creature called *Basilosaurus*.

Basilosaurus was a massive serpent-like sea monster that lived during the early age of whales. It was originally thought to be a reptile (the name means "king lizard"), but was soon reclassified as a mammal and a cousin of modern whales. Paleontologists now report that a *Basilosaurus* skeleton recently discovered in Egypt has appendages which appear to be vestigial hind legs and feet. The function these could have served is obscure. They are too small even to have been much assistance in swimming, and could not conceivably have supported the huge body on land. The fossil's discoverers speculate that the appendages may have been used as an aid to copulation.

Accounts of the fossil in the scientific journals and in the newspapers present the find as proof that whales once walked on legs and therefore descended from land mammals. None of these accounts mentions the existence of any unresolved problems in the whale evolution scenario, but the problems are immense. Whales

have all sorts of complex equipment to permit deep diving, underwater communication by sound waves, and even to allow the young to suckle without taking in sea water. Step-by-step adaptive development of each one of these features presents the same problems discussed in connection with wings and eyes in Chapter Three. Even the vestigial legs present problems. By what Darwinian process did useful hind limbs wither away to vestigial proportions, and at what stage in the transformation from rodent to sea monster did this occur? Did rodent forelimbs transform themselves by gradual adaptive stages into whale flippers? We hear nothing of the difficulties because to Darwinists unsolvable problems are not important.

Darwin conceded that the fossil evidence was heavily against his theory, and this remains the case today. It is therefore not surprising that Darwinist science has turned its attention to the newly discovered molecular evidence, and claimed that here at last is where conclusive proof of the Darwinian model can be found. We will look at that claim in the next chapter.

leading primate expert, is a good scientific materialist who regards the evolution of man from apes as self-evident, but who also regards much of the fossil evidence as poppycock. Zuckerman subjected the *Australopithecines* to years of intricate "biometric" testing, and concluded that "the anatomical basis for the claim that [they] walked and ran upright like man is so much more flimsy than the evidence which points to the conclusion that their gait was some variant of what one sees in subhuman Primates, that it remains unacceptable."

Zuckerman's judgment of the professional standards of physical anthropology was not a generous one: he compared it to parapsychology and remarked that the record of reckless speculation in human origins "is so astonishing that it is legitimate to ask whether much science is yet to be found in this field at all." The anthropologists not surprisingly resented that judgment, which would have left them with no fossils and no professional standing. Wilfred Le Gros Clark performed a rival study that came to more acceptable conclusions, and the consensus of the experts, meaning those who had the most to lose, was that Zuckerman was a curmudgeon with no real feel for the subject. The biometric issues are technical, but the real dispute was a conflict of priorities. Zuckerman's methodological premise was that the first priority of human origins researchers should be to avoid embarrassments like the Piltdown and Nebraska Man fiascos, not to find fossils that they can plausibly proclaim as ancestors. His factual premise was that the variation among ape fossils is sufficiently great that a scientist whose imagination was fired by the desire to find ancestors could easily pick out some features in an ape fossil and decide that they were "pre-human." Granted these two premises, it followed that all candidates for "ancestor" status should be subjected to a rigorous objective analysis, and rejected if the analysis was either negative or inconclusive.

Zuckerman understood that it was probable that none of the ape-like hominid fossils would be able to pass this kind of test, and that as a consequence fossil evidence of human evolution might be limited to specimens like Neanderthal Man that are human or nearly human. The absence of direct evidence for an ape-man transition did not trouble him, because he assumed that the Darwinian model was established for humans as well as other species on logical grounds. Besides, evidence of ancestral relationships is in

general absent from the fossil record. That being the case, it should be cause for suspicion rather than congratulation if there were a surfeit of ancestors in the one area in which human observers are most likely to give way to wishful thinking.

Zuckerman's position might have seemed reasonable to persons with no great stake in the question, but one also has to consider the cultural and economic aspects of the situation. The story of human descent from apes is not merely a scientific hypothesis; it is the secular equivalent of the story of Adam and Eve, and a matter of immense cultural importance. Propagating the story requires illustrations, museum exhibits, and television reenactments. It also requires a priesthood, in the form of thousands of researchers, teachers, and artists who provide realistic and imaginative detail and carry the story out to the general public. The needs of the public and the profession ensure that confirming evidence will be found, but only an audit performed by persons not committed in advance to the hypothesis under investigation can tell us whether the evidence has any value as confirmation.

For all these reasons I do not accept the alleged hominid species as independently observed data which can confirm the Darwinian model. I should add, however, that this degree of skepticism is not necessary to make the point that the hominid series cited by Gould is open to question. Some experts in good standing doubt, for example, that *A. Afarensis* and *A. Africanus* were really distinct species, and many deny that there ever was such a species as *Homo habilis*. The most exciting hypothesis in the field right now is the "mitochondrial Eve" theory based upon the molecular clock hypothesis discussed in Chapter Seven, which asserts that modern humans emerged from Africa less than 200,000 years ago. If that hypothesis is accepted, then all the *Homo erectus* fragments found outside of Africa are necessarily outside the ancestral chain, because they are older than 200,000 years.

Still, I am happy to assume *arguendo* that small apes (the *Australopithecines*) once existed which walked upright, or more nearly upright than apes of today, and that there may also have been an intermediate species (*Homo erectus*) that walked upright and had a brain size intermediate between that of modern men and apes. On that assumption there are possible transitional steps between apes and humans, but nothing like the smooth line of development that

arvensis, *A. africanus*, *Homo habilis*, *H. Erectus*, and *H. Sapiens*), to mimic a continuous trend of evolutionary change?²

That way of putting the question makes it sound as if Darwin proposed his theory because the presence of an abundance of fossil intermediates between apes and humans required some explanatory hypothesis. Of course what actually happened is that the theory was accepted first, and the supporting evidence was discovered and interpreted in the course of a determined effort to find the "missing links" that the theory demanded. The question this sequence of events raises is not whether God has been planting fossil evidence to test our faith in Genesis, but whether the Darwinist imagination might have played an important role in construing the evidence which has been offered to support Darwin's theory.

Physical anthropology—the study of human origins—is a field that throughout its history has been more heavily influenced by subjective factors than almost any other branch of respectable science. From Darwin's time to the present the "descent of man" has been a cultural certainty begging for empirical confirmation, and worldwide fame has been the reward for anyone who could present plausible fossil evidence for missing links. The pressure to find confirmation was so great that it led to one spectacular fraud, Piltdown man—which British Museum officials zealously protected from unfriendly inspection, allowing it to perform forty years of useful service in molding public opinion.

Museum reconstructions based on the scanty fossil evidence have had a powerful impact on the public imagination, and the fossils themselves have had a similar effect upon the anthropologists. The psychological atmosphere that surrounds the viewing of hominid fossils is uncannily reminiscent of the veneration of relics at a medi-

² The four ape-man species that Gould cites include the two *Australopithecines* on the ape side of the boundary, which had ape brains but are supposed to have walked upright, and the larger-brained *Homo* specimens. Louis Leakey's *Homo habilis* (handy man) is at the borderline and was granted *Homo* status mainly because it was found at a site with primitive tools, which it is presumed to have used. Readers who learned about this subject in school may be surprised to find out that *Neanderthal* man is frequently considered a subgroup within our own species and *Cro-Magnon* man is simply modern man. Some other familiar names were either dropped from the pantheon or absorbed into the four species. Hominid fossil classification is a fiercely controversial subject and was in chaos until the ubiquitous Ernst Mayr stepped in and set the ground rules.

eval shrine. That is just how Roger Lewin described the scene at the 1984 *Ancestors* exhibition at the American Museum of Natural History, an unprecedented showing of original fossils relating to human evolution from all over the world.

The "priceless and fragile relics" were carried by anxious curators in first-class airplane seats and brought to the Museum in a VIP motorcade of limousines with police escort. Inside the Museum, the relics were placed behind bullet-proof glass to be admired by a select preview audience of anthropologists, who spoke in hushed voices because "It was like discussing theology in a cathedral." A sociologist observing this ritual of the anthropologist tribe remarked, "Sounds like ancestor worship to me."

Lewin considers it understandable that anthropologists observing the bones of their ancestors should be more emotionally involved with their subject than other kinds of scientists. "There is a difference. There is something inexpressibly moving about cradling in one's hands a cranium drawn from one's own ancestry." Lewin is absolutely correct, and I can't think of anything more likely to detract from the objectivity of one's judgment. Descriptions of fossils from people who yearn to cradle their ancestors in their hands ought to be scrutinized as carefully as a letter of recommendation from a job applicant's mother. In his book *Human Evolution*, Lewin reports numerous examples of the subjectivity that is characteristic of human origins research, leading him to conclude that the field is invisibly but constantly influenced by humanity's shifting self-image. In plain English, that means that we see what we expect to see unless we are extremely rigorous in checking our prejudice.

Anthropologists do criticize each other's work, of course—their ferocious personal rivalries are partly responsible for the subjectivity of their judgments—but the question they debate is *whose* set of fossil candidates tells the story of human evolution most accurately, not *whether* fossil proof of the ape-human transition exists. For those who have chosen to devote their lives to exploring exactly how humans evolved from apes, persons who doubt the basic premise are by definition creationists, and hence not to be taken seriously. That there might be no reliable fossil evidence of human evolution is out of the question.

A prestigious outsider, however, has proposed the unthinkable. Solly Zuckerman, one of Britain's most influential scientists and a

species in the direct line of transition would have had to exist, but the fossil record fails to record them.

Reptile to Bird

Archaeopteryx ("old wing"), a fossil bird which appears in rocks estimated to be 145 million years old, was discovered soon after the publication of *The Origin of Species*, and it thus helped enormously to establish the credibility of Darwinism and to discredit skeptics like Agassiz. *Archaeopteryx* has a number of skeletal features which suggest a close kinship to a small dinosaur called *Compsognathus*. It is on the whole bird-like, with wings, feathers, and wishbone, but it has claws on its wings and teeth in its mouth. No modern bird has teeth, although some ancient ones did, and there is a modern bird, the hoatzin, which has claws.

Archaeopteryx is an impressive mosaic. The question is whether it is proof of a reptile (dinosaur) to bird transition, or whether it is just one of those odd variants, like the contemporary duck-billed platypus, that have features resembling those of another class but are not transitional intermediates in the Darwinian sense. Until very recently, the trend among paleontologists was to regard *Archaeopteryx* as an evolutionary dead end rather than as the direct ancestor of modern birds. The next oldest bird fossils were specialized aquatic divers that did not look like they could be its direct descendants.¹

The picture has changed somewhat following discoveries of fossil birds, one in Spain and the other in China, in rocks dated at 125 million and 135 million years. The new specimens have reptilian skeletal features which qualify them as possible intermediates between *Archaeopteryx* and certain modern birds. The evidence, however, is too fragmentary to justify any definite conclusions. According to a 1990 review article by Peter Wellnhofer, a recognized authority, it is impossible to determine whether *Archaeopteryx* actually was the ancestor of modern birds. Wellnhofer concludes that "this correlation is not of major importance," because the *Ar-*

¹ A paleontologist named Chatterjee claims to have found fossil evidence of a bird he calls *Protoavis*, in Texas rocks estimated to be 225 million years old. Bird fossils substantially older than 145 million years would disqualify *Archaeopteryx* as a bird ancestor, but Chatterjee's claim has been disputed.

chaeopteryx specimens "provide clues as to how birds evolved," and because "They are documents without which the idea of evolution would not be as powerful."

In *Archaeopteryx* we therefore have a possible bird ancestor rather than a certain one. As in the cases of mammals, there is plenty of difficulty in imagining how any single ancestor could have produced descendants as varied as the penguin, the hummingbird, and the ostrich, through viable intermediate stages. The absence of fossil evidence for the transitions is more easily excused, however, because birds pursue a way of life that ensures that their bodies will rarely be fossilized.

Archaeopteryx is on the whole a point for the Darwinists, but how important is it? Persons who come to the fossil evidence as convinced Darwinists will see a stunning confirmation, but skeptics will see only a lonely exception to a consistent pattern of fossil disconfirmation. If we are testing Darwinism rather than merely looking for a confirming example or two, then a single good candidate for ancestor status is not enough to save a theory that posits a worldwide history of continual evolutionary transformation.

Whatever one concludes about *Archaeopteryx*, the origin of birds presents many mysteries. Flight had to evolve, along with the intricate feathers and other specialized equipment, including the distinctive avian lung. Possibly birds did somehow develop from dinosaur predecessors, with *Archaeopteryx* as a way station, but even on this assumption we do not know what mechanism could have produced all the complex and interrelated changes that were necessary for the transformation.

From Apes to Humans

In the 1981 "Fact and Theory" article discussed in the preceding chapter, Gould cited the "half-dozen human species discovered in ancient rocks" as proof that humans evolved from apes. When he published a revised version of the same argument in 1987, the number of species had been reduced to five, one of which was *Homo sapiens* itself, but the point was the same:

Would God—for some inscrutable reason, or merely to test our faith—create five species, one after the other (*Australopithecus af-*

The lower jaw of reptiles contains several bones, that of mammals only one. The non-mammalian jawbones are reduced, step by step, in mammalian ancestors until they become tiny nubbins located at the back of the jaw. The 'hammer' and 'anvil' bones of the mammalian ear are descendants of these nubbins. How could such a transition be accomplished? the creationists ask. Surely a bone is either entirely in the jaw or in the ear. Yet paleontologists have discovered two transitional lineages of therapsids (the so-called mammal-like reptiles) with a double jaw joint—one composed of the old quadrate and articular bones (soon to become the hammer and anvil), the other of the squamosal and dentary bones (as in modern mammals).

We may concede Gould's narrow point, but his more general claim that the mammal-reptile transition is thereby established is another matter. Creatures have existed with a skull bone structure intermediate between that of reptiles and mammals, and so the transition with respect to this feature is possible. On the other hand, there are many important features by which mammals differ from reptiles besides the jaw and ear bones, including the all-important reproductive systems. As we saw in other examples, convergence in skeletal features between two groups does not necessarily signal an evolutionary transition.

Douglas Futuyma makes a confident statement about the therapsids that actually reveals how ambiguous the therapsid fossils really are. He writes that "The gradual transition from therapsid reptiles to mammals is so abundantly documented by scores of species in every stage of transition that it is impossible to tell which therapsid species were the actual ancestors of modern mammals." But large numbers of eligible candidates are a plus only to the extent that they can be placed in a single line of descent that could conceivably lead from a particular reptile species to a particular early mammal descendant. The presence of similarities in many different species that are outside of any possible ancestral line only draws attention to the fact that skeletal similarities do not necessarily imply ancestry. The notion that mammals-in-general evolved from reptiles-in-general through a broad clump of diverse therapsid lines is not Darwinism. Darwinian transformation requires a single line of ancestral descent.

It seems that the mammal-like qualities of the therapsids were distributed widely throughout the order, in many different sub-

groups which are mutually exclusive as candidates for mammal ancestors. An artificial line of descent can be constructed, but only by arbitrarily mixing specimens from different subgroups, and by arranging them out of their actual chronological sequence. If our hypothesis is that mammals evolved from therapsids only once (a point to which I shall return), then most of the therapsids with mammal-like characteristics were not part of a macroevolutionary transition. If most were not then perhaps all were not.

The case for therapsids as an ancestral chain linking reptiles to mammals would be a great deal more persuasive if the chain could be attached to something specific at either end. Unfortunately, important structural differences among the early mammals make it just as difficult to pick a specific mammal descendant as it is to pick any specific therapsid ancestors. This baffling situation led some paleontologists to consider a disturbing theory that mammals, long assumed to be a natural "monophyletic" group (that is, descended from a common mammalian ancestor) were actually several groups which had evolved separately from different lines of therapsids.

Turning mammals into a polyphyletic group would make therapsids more plausible as ancestors, but only at the unacceptable cost of undermining the Darwinist argument that mammalian homologies are relics of common ancestry. Whether mammals evolved more than once remains an open question as far as fossils are concerned, but the prestigious George Gaylord Simpson lowered the stakes considerably by deciding that a group could reasonably be considered monophyletic if it descended from a single unit of lower rank in the taxonomic hierarchy. Having arisen from the order *Therapsida*, the class *Mammalia* was acceptable as a natural unit.

If one does not stop with the reptile-mammal transition but continues the attempt to provide a coherent account of macroevolution into the mammal class itself, it becomes immediately apparent that there is a great deal more to explain than the differences in jaw and ear bone structure between reptiles and mammals. The mammal class includes such diverse groups as whales, porpoises, seals, polar bears, bats, cattle, monkeys, cats, pigs, and opossums. If mammals are a monophyletic group, then the Darwinian model requires that every one of the groups have descended from a single unidentified small land mammal. Huge numbers of intermediate

evolution has meant success in identifying ancestors, which provides an incentive for establishing criteria that will permit ancestors to be identified. Gareth Nelson of the American Museum of Natural History has expressed in plain language what this has meant in practice:

"We've got to have some ancestors. We'll pick those." Why? "Because we know they have to be there, and these are the best candidates." That's by and large the way it has worked. I am not exaggerating.

Obviously, "ancestors" cannot confirm the theory if they were labelled as such only because the theory told the researchers that ancestors had to be there.

Now let's look at the vertebrate sequence.

Fish to Amphibians

The story to be tested is that a fish species developed the ability to climb out of the water and move on land, while evolving the peculiar reproductive system of amphibians and other amphibian features more or less concurrently. No specific fossil fish species has been identified as an amphibian ancestor, but there is an extinct order of fish known as the rhipidistians which Darwinists frequently describe as an "ancestral group." The rhipidistians have skeletal features resembling those of early amphibians, including bones that look like they could have evolved into legs. But according to Barbara J. Stahl's comprehensive textbook, *Vertebrate History*, "none of the known fishes is thought to be directly ancestral to the earliest land vertebrates. Most of them lived after the first amphibians appeared, and those that came before show no evidence of developing the stout limbs and ribs that characterized the primitive tetrapods."

In 1938, a coelacanth (pronounced see-la-kanth), an ancient fish thought to have been extinct for about seventy million years, was caught by fishermen in the Indian Ocean. Many paleontologists considered the coelacanth to be closely related to the rhipidistians, and thus a living specimen was expected to shed light on the soft body parts of the immediate ancestors of amphibians. When the modern coelacanth was dissected, however, its internal organs showed no signs of being preadapted for a land environment and

gave no indication of how it might be possible for a fish to become an amphibian. The experience suggests that a rhipidistian fish might be equally disappointing to Darwinists if its soft body parts could be examined.

Amphibians to Reptiles

No satisfactory candidates exist to document this transition. There are fossil amphibians called *Seymouria* that have some reptile-like skeletal characteristics, but they appear too late in the fossil record and recent evidence indicates that they were true amphibians. The transition is in any case one which would be hard to confirm with fossils, because the most important difference between amphibians and reptiles involves the unfossilized soft parts of their reproductive systems. Amphibians lay their eggs in water and the larvae undergo a complex metamorphosis before reaching the adult stage. Reptiles lay a hard shell-cased egg and the young are perfect replicas of adults on first emerging. No explanation exists for how an amphibian could have developed a reptilian mode of reproduction by Darwinian descent.

Reptiles to Mammals

We come at last to the crown jewel of the fossil evidence for Darwinism, the famous mammal-like reptiles cited by Gould and many others as conclusive proof. The large order *Therapsida* contains many fossil species with skeletal features that appear to be intermediate between those of reptiles and mammals. At the boundary, fossil reptiles and mammals are difficult to tell apart. The usual criterion is that a fossil is considered reptile if its jaw contains several bones, of which one, the articular bone, connects to the quadrate bone of the skull. If the lower jaw consists of a single dentary bone, connecting to the squamosal bone of the skull, the fossil is classified as a mammal.

In this critical feature of jaw structure, and in some other features, various "therapsids" approach the mammalian characteristics so closely that in some cases they could be reasonably classified as either reptiles or mammals. Gould's vivid description brings out the importance of this:

That brings us to Gould's third proof, which takes us back to the fossil record. Gould concedes that fossil evidence of macroevolutionary transformations has rarely been found, but he insists that there are at least two instances in the vertebrate sequence where such transformations can be confirmed. One example is the "mammal-like reptiles," which, as the name implies, appear to be intermediates in the reptile-to-mammal transformation. The other is the hominids, or "ape-men," which are accepted by mainstream science as genuine predecessors of modern humans. This fossil evidence is the subject of the next chapter.

Chapter Six

The Vertebrate Sequence

DARWINISTS CLAIM THAT amphibians and modern fish descended from an ancestral fish; that reptiles descended from an amphibian ancestor; and that birds and mammals descended separately from reptile ancestors. Finally, they say that humans and modern apes had a common simian ancestor, from which modern humans descended through transitional intermediates that have been positively identified. According to Gould, fossils in the reptile-to-mammal and ape-to-human transitions provide decisive confirmation of the "fact of evolution."

Before going to the evidence I have to impose an important condition which is sure to make Darwinists very uncomfortable. It is that the evidence must be evaluated independently of any assumption about the truth of the theory being tested.

Paleontology, as we saw in Chapter Four, has taken Darwinian descent as a deductive certainty and has sought to flesh it out in detail rather than to test it. Success for fossil experts who study

capitulates phylogeny." That embryos actually recapitulate adult ancestral forms—that humans go through fish and reptile stages, for example—was never borne out by the evidence, and embryologists quietly discarded it. Nonetheless, the concept was so pleasing theoretically that generations of biology students learned it as fact. Gould recalls being taught the formula in school, fifty years after it had been discarded by science.

Although Haeckel's law has been discredited, another interpretation of the relationship between ontogeny and phylogeny survives under the name Von Baer's Law. This hypothesis asserts that resemblances among embryos reflect levels of biological classification, so that all vertebrates, for example, look very similar in early development but become increasingly dissimilar as they approach their adult forms. Futuyma's previously quoted statement encapsulates Von Baer's Law (though with overtones of Haeckel's). Darwin himself put the same point with his customary eloquence. Describing the facts of embryology to be "second to none" in importance for his theory, he remarked that the early embryo is "a picture, more or less obscured, of the progenitor, either in its adult or larval state, of all members of the same great class." Any exceptions to this rule of early embryonic resemblance, Darwin believed, could be explained as adaptations of larval stages to differing environments. Since a larva must compete for food and survive predators, it might be modified by natural selection, even though later stages would be unaffected.

This statement is tied to the basic logic of the Darwinian understanding of homology. If similarities inherited from an ancestral form are traceable to common developmental processes and common genes, it is logical to expect these ancestral features to be generated early in the process of embryonic development. The differing organisms in a single group (like vertebrates) should start out in life as relatively similar organisms and then form their differing features later. As with Haeckel's law, the picture is so pleasing that generations of biology students have been taught it as fact.

Unfortunately for the theory, however, the facts do not fit so neatly into the theoretical preconception. Far from providing the simple confirmation that Futuyma suggests, the embryonic patterns generate a monumental puzzle for the theory. Although it is true that vertebrates all pass through an embryonic stage at which they resemble each other, in fact they develop to this stage very differently. After

a vertebrate egg is fertilized, it undergoes cell divisions and cell movements characteristic of its class: fishes follow one pattern, amphibians another one, birds yet another, and mammals still another. The differences cannot be explained as larval adaptations, since these early stages occur before larvae form and thus are apparently not exposed to natural selection. Only by ignoring the early stages of development can one fit Darwin's theory to the facts of embryology, but it was precisely the early stages that Darwin claimed were the most significant!

The later stages of development are no more inclined to cooperate with Darwinian expectations than the earliest stages. The resemblances among bone structures in the limbs of vertebrates seem to suggest a common origin. As Gould rhetorically asks, why should they be so similar if not inherited from a common ancestor? But from a Darwinian perspective, genealogical continuity should be reflected in developmental continuity. In other words, similarity of pattern in the mature limb should reflect a repetition of ancestral patterns in the developing limb in the embryo. Unfortunately, detailed comparisons of limb development in fishes, birds and amphibians, and mammals show that this is not the case. On the contrary, the embryonic cells that give rise to limb bones exhibit patterns of division, branching, and cartilage production which differ from species to species without conforming to predictions based on the theory of common descent. By embryological criteria the similarities in vertebrate limbs resemble analogies more than homologies, and as such do not support Gould's claim that they are imperfections inherited from a common ancestor.

That vertebrate embryos develop along different pathways, only to converge in appearance midway through the process, then diverge again until they finally generate (in diverse ways) similar bone structures in their limbs are facts well known to embryologists. Conceivably there are ways for Darwinists to conform their theory to these baffling facts—if we assume *a priori* that the theory is true. That is not the question we are addressing now, however. The facts of homology and embryology have been alleged as straightforward confirmation of the "fact of evolution," and they are nothing of the kind. If embryology is our best guide to genealogy, as Darwin thought, our guide seems to be telling us that vertebrates have multiple origins and did not inherit their similarities from a common ancestor.

limits our comprehension of the difficulties by misleadingly covering them with the blanket term "evolution."

Could's second argument, and the centerpiece of his case for the "fact" of evolution, is the argument from imperfection:

The second argument—that the imperfection of nature reveals evolution—strikes many people as ironic, for they feel that evolution should be most elegantly displayed in the nearly perfect adaptation expressed by some organisms—the camber of a gull's wing, or butterflies that cannot be seen in ground litter because they mimic leaves so precisely. But perfection could be imposed by a wise creator or evolved by natural selection. Perfection covers the tracks of past history. And past history—the evidence of descent—is the mark of evolution.

Evolution lies exposed in the imperfections that record a history of descent. Why should a rat run, a bat fly, a porpoise swim, and I type this essay with structures built of the same bones unless we all inherited them from a common ancestor? An engineer, starting from scratch, could design better limbs in each case. Why should all the large native mammals of Australia be marsupials, unless they descended from a common ancestor on this island continent? Marsupials are not "better," or ideally suited for Australia; many have been wiped out by placental animals imported by man from other continents. . . .

Could here merely repeats Darwin's explanation for the existence of natural groups—the theory for which we are seeking confirmation—and gives it a theological twist. A proper Creator should have designed each kind of organism from scratch to achieve maximum efficiency. This speculation is no substitute for scientific evidence establishing the reality of the common ancestors. It also does nothing to confirm the natural process by which the transformation from ancestral to descendant forms supposedly occurred. It is Darwin, after all, who banished speculation about the "unknown plan of creation" from science.

Douglas Futuyma also leans heavily on the "God wouldn't have done it" theme, citing examples from vertebrate embryology:

Why should species that ultimately develop adaptations for utterly different ways of life be nearly indistinguishable in their early stages?

How does God's plan for humans and sharks require them to have almost identical embryos? Why should terrestrial salamanders, if they were not descended from aquatic ancestors, go through a larval stage entirely within the egg, with gills and fins that are never used, and then lose these features before they hatch?

These are rhetorical questions, but they point to legitimate starting points for investigation. The features Futuyma cites may exist because a Creator employed them for some inscrutable purpose; or they may reflect inheritance from specific common ancestors; or they may be due to some as yet unimagined process which science may discover in the future. The task of science is not to speculate about why God might have done things this way, but to see if a evolutionary biology is to be a science rather than a branch of philosophy; its theorists have to be willing to ask the scientific question: *How can Darwin's hypothesis of descent with modification be confirmed or falsified?*

Could and Futuyma point us toward one way of answering that question. From Darwin's time to the present, evolutionary biologists have believed that common descent implies some very important propositions about homology and embryonic development. If homologous features are relics of common ancestry, they ought to be traceable to common embryonic parts. Conversely, if parts that appear to be homologous in adult organisms were shown to have developed very differently in the embryo, this would be evidence that they evolved separately and are therefore not inherited from a common ancestor. This correspondence between homology in the adult and embryonic forms seemed so logically inescapable to Darwin that in the sixth edition of *The Origin of Species* he defined "homology" as "that relation between parts that results from their development from corresponding embryonic parts." Genes were unknown in Darwin's time, but by extension of the same logic, modern biologists have assumed that the corresponding embryonic parts are themselves controlled by homologous genes.

Darwin's definition of homology reflected a widespread belief among evolutionists that there is a profound relationship between ontogeny and phylogeny—i.e., between embryonic development and evolutionary history. In the early years this concept was expressed in Ernst Haeckel's so-called Biogenetic Law: "Ontogeny re-

natural selection is then assured because it is a necessary implication of the "fact" that evolution has produced all the wonders of biology. Recasting the theory as fact serves no purpose other than to protect it from falsification.

Nobody needs to prove that apples fall down rather than up, but Gould provides three proofs for the "fact of evolution." The first proof is microevolution:

First, we have abundant, direct, observational evidence of evolution in action, from both field and laboratory. This evidence ranges from countless experiments on change in nearly everything about fruit flies subjected to artificial selection in the laboratory to the famous populations of British moths that became black when industrial soot darkened the trees upon which the moths rest. (Moths gain protection from sharp-sighted bird predators by blending into the background.) Creationists do not deny these observations: how could they? Creationists have tightened their act. They now argue that God only created "basic kinds," and allowed for limited evolutionary meandering within them. Thus toy poodles and Great Danes come from the dog kind and moths can change color, but nature cannot convert a dog to a cat or a monkey to a man.

Gould is right: everyone agrees that microevolution occurs, including creationists. Even creation-scientists concur, not because they "have tightened their act," but because their doctrine has always been that God created basic kinds, or types, which subsequently diversified. The most famous example of creationist microevolution involves the descendants of Adam and Eve, who have diversified from a common ancestral pair to create all the diverse races of the human species.

The point in dispute is not whether microevolution happens, but whether it tells us anything important about the processes responsible for creating birds, insects, and trees in the first place. Gould himself has written that even the first step toward macroevolution (speciation) requires more than the accumulation of micromuta-

be worth much if it could not explain the origin of complex biological structures, and nobody has found a naturalistic alternative to micromutation and selection for that purpose. Even Gould has to rely upon orthodox Darwinism when he looks away from the fossil problem and turns to justifying "evolution" as a general explanation for the origin of complex biological structures like wings and eyes.

tions. Instead of explaining how the peppered moth variations bear on the kind of evolution that really matters, however, he changes the subject and takes a swipe at creationists.²

Other Darwinists who do not simply ignore the problem resort to bad philosophy to evade it. For example, Mark Ridley asserts that "All that is needed to prove evolution is observed microevolution added to the philosophical doctrine of uniformitarianism which (in the form that is needed here) underlies all science."

But what sort of proof is this? If our philosophy demands that small changes add up to big ones, then the scientific evidence is irrelevant. Scientists like to assume that the laws of nature were always and everywhere uniform, because otherwise they could not make inferences about what happened in the distant past or at the opposite end of the universe. They do not assume that the rules which govern activity at one level of magnitude necessarily apply at all other levels. The differences between Newtonian physics, relativity, and quantum mechanics show how unjustified such an assumption would be. What the Darwinists need to supply is not an arbitrary philosophical principle, but a scientific theory of how macroevolution can occur.

Much confusion results from the fact that a single term—"evolution"—is used to designate processes that may have little or nothing in common. A shift in the relative numbers of dark and light moths in a population is called evolution, and so is the creative process that produced the cell, the multicellular organism, the eye, and the human mind. The semantic implication is that evolution is fundamentally a single process, and Darwinists enthusiastically exploit that implication as a substitute for scientific evidence. Even the separation of evolution into its "micro" and "macro" varieties—which Darwinists generally resist—implies that all the creative processes involved in life comprise a single, two-part phenomenon that will be adequately understood when we discover a process that makes new species from existing ones. Possibly this is the case, but more probably it is not. The vocabulary of Darwinism inherently

² Creationist-bashing as a substitute for evidence is common in Darwinist polemics. For example, Isaac Asimov's 884-page *New Guide to Science* has a half-page section on the evidence for Darwinism, which cites the peppered moth example as sufficient to prove the whole theory. This is preceded by almost three pages abusing creationists. The lapse from professionalism is striking, because on other topics the book is admirably scientific.

what you will against every detail," they respond, "still, nothing in biology makes sense except in the light of evolution."

Darwin's theory unquestionably has impressive explanatory power, but how are we to tell if it is *true*? If we define "evolution" simply as "whatever produces classification," then evolution is a fact in the same sense that classification is a fact. This is another tautology, however, and as such it has no genuine explanatory value. In this form the theory is supported mainly by the semantic implications of the word "relationship." Darwinists assume that the relationship between, say, bats and whales is similar to that between siblings and cousins in human families. Possibly it is, but the proposition is not self-evident.

Descent with modification could be something much more substantial than a tautology or a semantic trick. It could be a testable scientific hypothesis. If common ancestors and chains of linking intermediates once existed, fossil studies should be able, at least in some cases, to identify them. If it is possible for a single ancestral species to change by natural processes into such different forms as a shark, a frog, a snake, a penguin, and a monkey, then laboratory science should be able to discover the mechanism of change.

If laboratory science cannot establish a mechanism, and if fossil studies cannot find the common ancestors and transitional links, then Darwinism fails as an empirical theory. But Darwinists suppress consideration of that possibility by invoking a distinction between the "fact" of evolution and Darwin's particular theory. Objections based upon the fossil record and the inadequacy of the Darwinist mechanism go only to the theory, they argue. Evolution itself (the logical explanation for relationships) remains a fact, by which they seem to mean it is an inescapable deduction from the fact of relationship. Stephen Jay Gould's influential article, "Evolution as Fact and Theory" explains the distinction by citing the fact and theory of gravity:

Facts are the world's data. Theories are structures of ideas that explain and interpret facts. Facts do not go away while scientists debate rival theories for explaining them. Einstein's theory of gravitation replaced Newton's, but apples did not suspend themselves in mid-air pending the outcome. And human beings evolved from ape-like

ancestors whether they did so by Darwin's proposed mechanism or by some other, yet to be identified.

The analogy is spurious. We observe directly that apples fall when dropped, but we do not observe a common ancestor for modern apes and humans. What we *do* observe is that apes and humans are physically and biochemically more like each other than they are like rabbits, snakes, or trees. The ape-like common ancestor is a hypothesis in a *theory*, which purports to explain how these greater and lesser similarities came about. The theory is plausible, especially to a philosophical materialist, but it may nonetheless be false. The true explanation for natural relationships may be something much more mysterious.

Because Gould draws the line between fact and theory in the wrong place, the distinction is virtually meaningless. The theory to him is merely the theory of natural selection, and the "fact" is the fact that evolution may occur by chance mechanisms without influence from selection. Gould explains the distinction by observing that

while no biologist questions the importance of natural selection, many now doubt its ubiquity. In particular, many evolutionists argue that substantial amounts of genetic change may not be subject to natural selection and may spread through populations at random.

As Gould acknowledges, however, Darwin always insisted that natural selection was only *one* of the mechanisms of evolution, and complained bitterly when he was accused of writing that selection is ubiquitous. The "fact" that Gould describes is therefore nothing but Darwin's *theory* rightly understood: evolution is descent with modification propelled by random genetic changes, with natural selection providing whatever guidance is needed to produce complex adaptive structures like wings and eyes.¹ The creative power of

¹ Readers should not be misled by the daring speculations of a few paleontologists like Gould and Steven Stanley, who flirt with macromutational alternatives to Darwinist gradualism. No there have been paleontologists who acknowledged that the fossil record is inconsistent with strict Darwinism. To mitigate the difficulty, they have tried to describe a saltationist alternative in language the punists could tolerate.

The fossil problem, however, is not the main issue. A fact or theory of evolution would not

whale should be grouped with the horse and the monkey as mammals, despite the enormous differences in behavior and adaptive mechanisms. Bees are built on a fundamentally different body plan from vertebrates of any kind, and go into a different series of groupings altogether.

Biologists before and after Darwin have generally sensed that in classifying they were not merely forcing creatures into arbitrary categories, but discovering relationships that are in some sense real. Some pre-Darwinian taxonomists expressed this sense by saying that whales and bats are superficially like fish and birds but they are *essentially* mammals—that is, they conform in their “essence” to the mammalian “type.” Similarly, all birds are essentially birds, whether they fly, swim, or run. The principle can be extended up or down the scale of classification: St. Bernards and dachshunds are essentially dogs, despite the visible dissimilarity, and sparrows and elephants are essentially vertebrates.

Essentialism did not attempt to explain the cause of natural relationships, but merely described the pattern in the language of Platonic philosophy. The essentialists knew about fossils and hence were aware that different kinds of creatures had lived at different times. The concept of evolution did not make sense to them, however, because it required the existence of numerous intermediates—impossible creatures that were somewhere in transition from one essential state to another. Essentialists therefore attributed the common features linking each class not to inheritance from common ancestors, but to a sort of blueprint called the “Archetype,” which existed only in some metaphysical realm such as the mind of God.

Darwin proposed a naturalistic explanation for the essentialist features of the living world that was so stunning in its logical appeal that it conquered the scientific world even while doubts remained about some important parts of his theory. He theorized that the discontinuous groups of the living world were the descendants of long-extinct common ancestors. Relatively closely related groups (like reptiles, birds, and mammals) shared a relatively recent common ancestor; all vertebrates shared a more ancient common ancestor; and all animals shared a still more ancient common ancestor. He then proposed that the ancestors must have been linked to their descendants by long chains of transitional intermediates, also extinct. According to Darwin:

We may thus [by extinction] account even for the distinctness of whole classes from each other—for instance, of birds from all other vertebrate animals—by the belief that many ancient forms of life have been utterly lost, through which the early progenitors of birds were formerly connected with the early progenitors of the other vertebrate classes.

This theory of descent with modification made sense out of the pattern of natural relationships in a way that was acceptable to philosophical materialists. It explained why the groups seemed to be part of the natural framework rather than a mere human invention—to the Darwinist imagination, they are literally families. When combined with the theory of natural selection, it explained the difference between the common features that are relevant to classification (*homologies*) and those that are not (*analogies*). The former were relics of the common ancestor; the latter evolved independently by natural selection to provide very different creatures with superficially similar body parts that were useful to such adaptive strategies as flight and swimming. In Darwin's historic words:

All the . . . difficulties in classification are explained . . . on the view that the natural system is founded on descent with modification: that the characters which naturalists consider as showing true affinity between any two or more species, are those which have been inherited from a common parent, and in so far, all true classification is genealogical; that community of descent is the hidden bond which naturalists have been unconsciously seeking; and not some unknown plan of creation, or the enunciation of general propositions, and the mere putting together and separating objects more or less alike.

Darwin ended his chapter by saying that the argument from classification was so decisive that on that basis alone he would adopt his theory even if it were unsupported by other arguments. That confidence explains why Darwin was discouraged by the manifold difficulties of the fossil record: his logic told him that descent with modification had to be the explanation for the “difficulties in classification,” regardless of any gaps in the evidence. The same logic inspires today's Darwinists, when they shrug off critics who claim that one element or another in the theory is doubtful. “Say

ticularly by Gould) they have always kept open their lines of retreat to orthodox Darwinian gradualism.

This raises the most basic question of all. If there are so many problems with Darwinism, and no satisfactory alternative within the framework of evolution, why not reevaluate the framework? What makes our scientists so absolutely certain that everything really *did* evolve from simple beginnings?

Chapter Five

The Fact of Evolution

DARWINISTS CONSIDER EVOLUTION to be a fact, not just a theory, because it provides a satisfying explanation for the pattern of relationship linking all living creatures—a pattern so identified in their minds with what they consider to be the necessary *cause* of the pattern—descent with modification—that, to them, biological relationship *means* evolutionary relationship.

Biological classification is about as controversial a subject as religion or politics, but some basic principles are generally accepted. Biologists classify animals (and other organisms) by taxonomic categories such as families, orders, classes, and phyla. A superficial classification might group the whale, the penguin, and the shark together as aquatic creatures, and birds, bats, and bees together as flying creatures. But the basic body design of birds, bats, and bees is fundamentally different, their reproductive systems are different, and even their wings are similar only in the sense that they are all fit for flying. Accordingly, all taxonomists agree that the bat and the

change we call stasis. . . . But insofar as evolution itself is concerned, paleontologists usually saw stasis as "no results" rather than as a contradiction of the prediction of gradual, progressive evolutionary change. Caps in the record continue (to this day) to be invoked as the prime reason why so few cases of gradual change are found.

Gould wrote in the same vein that "When Niles Eldredge and I proposed the theory of punctuated equilibrium in evolution, we did so to grant stasis in phylogenetic lineages the status of 'worth reporting'—for stasis had previously been ignored as nonevidence of evolution, though all paleontologists knew its high relative frequency." What Gould and Eldredge had to avoid, however, was what Eldredge described as "the not-unreasonable relegation to the lunar fringe that some paleontologists in the past had suffered when they too saw something out of kilter between contemporary evolutionary theory, on the one hand, and patterns of change in the fossil record on the other." In short, they had to avoid seeming to embrace saltationism.

In the preceding chapter I mentioned the paleontologist Otto Schindewolf, whose saltationism extended to the extreme of proposing that the first bird must have hatched from a reptile's egg. George Gaylord Simpson reviewed Schindewolf's book disapprovingly, but he conceded that its author's bizarre conclusions were based upon a thorough knowledge of the fossil evidence. The trouble with Schindewolf was that he made no attempt to impose an interpretation upon the fossil evidence which could be accepted by the geneticists, or perhaps he relied too much upon the approval of the geneticist Richard Goldschmidt. He just went ahead and published what the fossils told him, and the fossils said "saltation."

Paleontologists who have to work under the influence of neo-Darwinism do not have the same freedom to draw whatever conclusions their evidence leads them to. Eldredge has described the paleontologist's dilemma frankly: "either you stick to conventional theory despite the rather poor fit of the fossils, or you focus on the empirics and say that saltation looks like a reasonable model of the evolutionary process—in which case you must embrace a set of rather dubious biological propositions." Paleontology, it seems, is a discipline in which it is sometimes unseemly to "focus on the empirics." On the other hand, one can't just go out and manufacture

evidence of Darwinist evolution, and Eldredge wrote movingly about how this combination of restrictions makes it difficult to pursue a successful career:

Complicating the normal routine is the hassle of obtaining a Ph.D. A piece of doctoral research is really an apprenticeship, and the dissertation a comprehensive report that shows the candidate's ability to frame, and successfully pursue, an original piece of scientific research. Sounds reasonable, but the pressure for results, positive results, is enormous.

In these frustrating circumstances, paleontologists clearly needed to find a theory that would allow them to report their projects as successful, but they felt constrained to operate within the boundaries of the neo-Darwinian synthesis. What was required was a theory that was saltationist enough to allow the paleontologists to publish, but gradualistic enough to appease the Darwinists. Punctuated equilibrium accomplishes this feat of statesmanship by making the process of change inherently invisible. You can imagine those peripheral isolates changing as much and as fast as you like, because no one will ever see them.

Gould and Eldredge have consistently described punctuated equilibrium as a Darwinist theory, not a saltationist repudiation of Darwinism. On the other hand, it is easy to see how some people got the impression that saltationism was at least being hinted, if not explicitly advocated. Gould and Eldredge put two quotes by T. H. Huxley on the front of their 1977 paper, both complaints about Darwin's refusal to allow a little "saltus" in his theory. At about the same time, Gould independently endorsed a qualified saltationism and predicted Goldschmidt's vindication.

The trouble with saltationism, however, is that when closely examined it turns out to be only a meaningless middle ground somewhere between evolution and special creation. As Richard Dawkins put it, you can call the Biblical creation of man from the dust of the earth a saltation. In terms of fossil evidence, saltation just means that a new form appeared out of nowhere and we haven't the faintest idea how. As a scientific theory, "saltationist evolution" is just what Darwin called it in the first place: rubbish. Gould and Eldredge understand that, and so despite hints of saltationism (par-

can tell tales of improvement for some groups, but in honest moments we must admit that the history of complex life is more a story of multifarious variation about a set of basic designs than a saga of accumulating excellence.⁴ But Darwinist evolution should be a story of improvement in fitness,⁴ and so Gould regarded "the failure to find a clear 'vector of progress' in life's history as the most puzzling fact of the fossil record."

He thought the solution to the puzzle might lie in alternating periods of evolution by punctuated equilibrium on the one hand, and arbitrary extinction during catastrophes on the other. Under these circumstances evolution would not be a story of gradual adaptive improvement, but rather "Evolutionary success must be assessed among species themselves, not at the traditional Darwinian level of struggling organisms within populations." Adopting without hesitation the "tautology" formulation of natural selection at the species level, Gould proposed that "The reasons that species succeed are many and varied—high rates of speciation and strong resistance to extinction, for example—and often involve no reference to traditional expectations for improvement in morphological design."

Just about everyone who took a college biology course during the last sixty years or so has been led to believe that the fossil record was a bulwark of support for the classic Darwinian thesis, not a liability that had to be explained away. And if we didn't take a biology class we saw *Inherit the Wind* and laughed along with everybody else when Clarence Darrow made a monkey out of William Jennings Bryan. But I wonder if Bryan would have looked like such a fool if he could have found a distinguished paleontologist having one of those "honest moments," and produced him as a surprise witness to tell the jury and the theater audience that the fossil record shows a consistent pattern of sudden appearance followed by stasis, that life's history is more a story of variation around a set of basic designs than

⁴ Gould supported that point with a Darwin quote, but I will substitute a better one: "It may be said that natural selection is daily and hourly scrutinising, throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good: silently and insensibly working, whenever and wherever opportunity offers, at the improvement of each organic being in relation to its organic and inorganic condition of life." In later editions, Darwin added the word "metaphorically" to the sentence, apparently realizing that he had written of natural selection as if it were an intelligent, creative being.

one of accumulating improvement, that extinction has been predominantly by catastrophe rather than gradual obsolescence, and that orthodox interpretations of the fossil record often owe more to Darwinist preconception than to the evidence itself. Imagine the confusion that Bryan could have caused by demanding the right to read his own preferred evidence into those famous gaps! Why not, if Darwin could do it?

Paleontologists seem to have thought it their duty to protect the rest of us from the erroneous conclusions we might have drawn if we had known the actual state of the evidence. Gould described "the extreme rarity of transitional forms in the fossil record" as "the trade secret of paleontology." Steven Stanley explained that the doubts of paleontologists about gradualistic evolution were for long years "suppressed." He wrote that the process began with T. H. Huxley himself, who muted "his negative attitudes toward gradual change and natural selection," presumably because "as a believer, Huxley was not inclined to aid those who were disposed to throw the baby of evolution out with the bathwater of gradualistic natural selection." But why would Huxley fear that, unless the baby and the bathwater were impossible to separate?

Niles Eldredge has been even more revealing: "We paleontologists have said that the history of life supports [the story of gradual adaptive change], all the while really knowing that it does not." But how could a deception of this magnitude possibly have been perpetrated by the whole body of a respected science, dedicated almost by definition to the pursuit of truth? Eldredge's explanation is all too believable to anyone who is familiar with the ways of the academic world:

Each new generation, it seems, produces a few young paleontologists eager to document examples of evolutionary change in their fossils. The changes they have always looked for have, of course, been of the gradual, progressive sort. More often than not their efforts have gone unrewarded—their fossils, rather than exhibiting the expected pattern, just seem to persist virtually unchanged. . . . This extraordinary conservatism looked, to the paleontologist keen on finding evolutionary change, as if no evolution had occurred. Thus studies documenting conservative persistence rather than gradual evolutionary change were considered failures, and, more often than not, were not even published. Most paleontologists were aware of the stability, the lack of

If evolution could produce ten new Cambrian phyla and then wipe them out just as quickly, then what about the surviving Cambrian groups? Why should they have had a long and honorable Precambrian pedigree? Why should they not have originated just before the Cambrian, as the fossil record, read literally, seems to indicate, and as the fast-transition theory proposes?

An orthodox Darwinist would answer that a direct leap from unicellular organisms to 25 to 50 complex animal phyla without a long succession of transitional intermediates is not the sort of thing for which a plausible genetic mechanism exists, to put it mildly. Gould is describing something he calls "evolution," but the picture is so different from what Darwin and his successors had in mind that perhaps a different term ought to be found. The Darwinian model of evolution is what Gould calls the "cone of increasing diversity." This means that the story of multicellular animal life should begin with a small number of species evolving from simpler forms. The dozens of different basic body plans manifested in the Cambrian fossils would then be the product of a long and gradual process of evolution from less differentiated beginnings. Nor should the cone have stopped expanding abruptly after the Cambrian explosion. If the disconfirming facts were not already known, any Darwinist would be confident that the hundreds of millions of years of post-Cambrian evolution would have produced many new phyla.

Instead we see the basic body plans all appearing first, many of these becoming extinct, and further diversification proceeding strictly within the boundaries of the original phyla. These original Cambrian groups have no visible evolutionary history, and the "artifactual theory" which would supply such a history has to be discarded. Maybe a few evolutionary intermediates existed for some of the groups, although none have been conclusively identified, but otherwise just about all we have between complex multicellular animals and single cells is some words like "fast-transition." We can call this thoroughly un-Darwinian scenario "evolution," but we are just attaching a label to a mystery.

Sudden appearance and stasis of species in the fossil record is the opposite of what Darwinian theory would predict, and the pattern of extinctions is equally disappointing. There appear to have been a number of mass extinctions in the history of the earth, and debate

still continues about what caused them. Two catastrophes in particular stand out: the Permian extinction of about 245 million years ago, which exterminated half the families of marine invertebrates and probably more than 90 per cent of all species; and the famous "K-T" extinction at the end of the Cretaceous era, about 65 million years ago, which exterminated the dinosaurs and a great deal else besides, including those ammonites whose disappearance Darwin conceded to have been wonderfully sudden.

According to Gould, paleontologists have known about these "great dyings" all along, but they have tried to minimize their importance because "our strong biases for gradual and continuous change force us to view mass extinctions as anomalous and threatening." Catastrophic explanations of extinction are making a strong comeback, however, and many researchers now report that the mass extinctions were more frequent, more rapid, and more profound in their effects than had previously been acknowledged.

Catastrophism is a controversial subject among geologists and paleontologists. Many scientific papers have argued that dinosaurs and ammonites were disappearing from the earth for millions of years before the meteorite impact which may have set off the K-T catastrophe. The stakes in this esoteric controversy are high, because Darwinism requires that old forms (the missing ancestors and intermediates) die out gradually as they are replaced by better adapted new forms. A record of extinction dominated by global catastrophes, in which the difference between survival and extinction may have been arbitrary, is as disappointing to Darwinist expectations as a record of sudden appearance followed by stasis.

There will be new controversies about the fossils before long, and probably anything written today will be outdated within a few years. The point to remember, however, is that the fossil problem for Darwinism is getting worse all the time. Darwinist paleontologists are indignant when creationists point this out, but what they write themselves is extraordinarily revealing. As usual, Gould is the most interesting commentator.

After attending a geological conference on mass extinctions, Gould wrote a remarkable essay reflecting on how the evidence was turning against Darwinism. He told his readers that he had long been puzzled by the lack of evidence of progressive development over time in the invertebrates with which he was most familiar. "We

merous and long-lived. None of these appear in the fossil record. Of course the intermediates could have been very shortlived if they were not well fitted for survival, as would probably be the case with a creature midway in the process of changing legs to fins or wings. Raising this issue, however, adds nothing to the plausibility of the Darwinist scenario.

No doubt a certain amount of evolution could have occurred in such a way that it left no trace in the fossil record, but at some point we need more than ingenious excuses to fill the gaps. The discontinuities between the major groups—phyla, classes, orders—are not only pervasive, but in many cases immense. Was there never anything but invisible peripheral isolates in between?

The single greatest problem which the fossil record poses for Darwinism is the "Cambrian explosion" of around 600 million years ago. Nearly all the animal phyla appear in the rocks of this period, without a trace of the evolutionary ancestors that Darwinists require. As Richard Dawkins puts it, "It is as though they were just planted there, without any evolutionary history." In Darwin's time there was no evidence for the existence of pre-Cambrian life, and he conceded in *The Origin of Species* that "The case at present must remain inexplicable, and may be truly urged as a valid argument against the views here entertained." If his theory was true, Darwin wrote, the pre-Cambrian world must have "swarmed with living creatures."

In recent years evidence of bacteria and algae has been found in some of the earth's oldest rocks, and it is generally accepted today that these single-celled forms of life may have first appeared as long ago as four billion years. Bacteria and algae are "prokaryotes," which means each creature consists of a single cell without a nucleus and related organelles. More complex "eukaryote" cells (with a nucleus) appeared later, and then dozens of independent groups of multicellular animals appeared without any visible process of evolutionary development. Darwinist theory requires that there have been very lengthy sets of intermediate forms between unicellular organisms and animals like insects, worms, and clams. The evidence that these existed is missing, however, and with no good excuse.³

³ The picture is clouded slightly by uncertainty over the status of the Ediacarans, a group of soft-bodied, shallow-water marine invertebrates found in rocks dating from shortly before the

The problem posed by the Cambrian explosion has become known to many contemporary readers due to the success of Gould's book *Wonderful Life*, describing the reclassification of the Cambrian fossils known as the Burgess Shale. According to Gould, the discoverer of the Burgess Shale fossils, Charles Walcott, was motivated to "shoehorn" them into previously known taxonomic categories because of his predisposition to support what is called the "artifact theory" of the pre-Cambrian fossil record. In Gould's words:

Two different kinds of explanations for the absence of Precambrian ancestors have been debated for more than a century: the artifact theory (they did exist, but the fossil record hasn't preserved them), and the fast-transition theory (they really didn't exist, at least as complex invertebrates easily linked to their descendants, and the evolution of modern anatomical plans occurred with a rapidity that threatens our usual ideas about the stately pace of evolutionary change).

More recent investigation has shown that the Burgess Shale fossils include some 15 or 20 species that cannot be related to any known group and should probably be classified as separate phyla, as well as many other species that fit within an existing phylum but still manifest quite different body plans from anything known to exist later. The general picture of animal history is thus a burst of general body plans followed by extinction. No new phyla evolved thereafter. Many species exist today which are absent from the rocks of the remote past, but these all fit within general taxonomic categories present at the outset. The picture is one of evolution of a sort, but only within the confines of basic categories which themselves show no previous evolutionary history. Gould described the reclassification of the Burgess fossils as the "death knell of the artifact theory," because

Cambrian explosion. Some paleontologists have interpreted these as precursors to a few of the Cambrian groups. More recent studies by a paleontologist named Seilacher support the view, accepted by Gould, "that the Ediacaran fauna contains no ancestors for modern organisms, and that every Ediacaran animal shares a basic mode of organization quite distinct from the architecture of living groups." So interpreted, the Ediacarans actually demolish a standard Darwinist explanation for the absence of pre-Cambrian ancestors: that soft-bodied creatures would not fossilize. In fact many ancient soft-bodied fossils exist, in the Burgess Shale and elsewhere.

ciently to produce a new form in a single generation. Whether or not macromutations are involved, the most important concept of evolution by punctuated equilibrium, as developed by Gould and Eldredge, is that speciation (the formation of new species) occurs rapidly,² and in small groups which are isolated on the periphery of the geographical area occupied by the ancestral species. Selective pressures might be particularly intense in an area where members of the species are just barely able to survive, and favorable variations could spread relatively quickly through a small, isolated population. By this means a new species might arise in the peripheral area without leaving fossil evidence. Because fossils are mostly derived from large, central populations, a new species would appear suddenly in the fossil record following its migration into the central area of the ancestral range.

Punctuated equilibrium explains the prevalence of stasis in the fossil record by linking macroevolution with speciation. This identification is necessary, according to Eldredge and Gould, because in a large interbreeding population something called "gene flow" hinders evolution. What this means is simply that the effect of favorable mutations is diluted by the sheer bulk of the population through which they must spread. This factor explains why species seem so unchanging in the fossil record: the population as a whole is *not* changing. The important evolutionary change occurs only among the peripheral isolates, who rejoin the stable ancestral population "suddenly" after forming a new species.

Most evolutionary biologists do not accept Eldredge and Gould's hypothesis that evolutionary change is closely associated with speciation. A great deal of variation can be obtained within a biological species (remember those dogs), whereas separate species are often very similar in visible characteristics. Speciation and change in form therefore seem to be different phenomena. Whether dilution or "gene flow" actually impedes change in large populations is the

² Terms like "rapidly" in this connection refer to geological time, and readers should bear in mind that 100,000 years is a brief period to a geologist. The punctationalists' emphatic repudiation of "gradualism" is confusing, and tends to give the impression they are advocating salationism. What they seem to mean is that the evolutionary change occurs over many generations by Darwin's step-by-step method, but in a relatively brief period of geological time. The ambiguity may be deliberate, however, for reasons that will be explained in this chapter.

subject of an apparently unresolvable theoretical dispute. Evidence that daughter populations form and then rejoin the parent species is lacking. According to Douglas Futuyma, "few if any" examples have been documented of an ancestral form persisting in the same region with a modified descendant.

For these and other reasons, orthodox neo-Darwinists prefer to explain sudden appearance on the traditional basis of gaps in the fossil record, and stasis as a reflection of "mosaic evolution" and "stabilizing selection." The former means that the soft body parts might have been evolving invisibly while the parts which fossilized stayed the same. The latter means that natural selection prevented change by eliminating all the innovations, sometimes for periods of millions of years and despite changing environmental conditions that ought to have encouraged adaptive innovation. Natural selection appears here in its formulation as a tautology with rather too much explanatory power, an invisible all-purpose explanation for whatever change or lack of change happened to occur.

If Darwinism enjoys the status of an *a priori* truth, then the problem presented by the fossil record is how Darwinist evolution always happened in such a manner as to escape detection. If, on the other hand, Darwinism is a scientific hypothesis which can be confirmed or falsified by fossil evidence, then the really important thing about the punctationalism controversy is not the solution Gould, Eldredge, and Stanley proposed but the problem to which they drew attention. I see no reason to doubt that punctationalism is a valid model for evolution in some cases. There are instances, such as the proliferation of fruitfly species in Hawaii, where it appears that rapid diversification has occurred following an initial migration of a parent species into a new region. The important question is not whether rapid speciation in peripheral isolates has occurred, however, but whether this mechanism can explain more than a relatively narrow range of modifications which cross the species boundary but do not involve major changes in bodily characteristics.

Consider the problem posed by Stanley's example of whales and bats, a mid-range case involving change within a single class. Nobody is proposing that an ancestral rodent (or whatever) became a whale or a bat in a single episode of speciation, with or without the aid of a mutation in its regulatory genes. Many intermediate species would have had to exist, some of which ought to have been nu-

confirmed by the fossils (a declaration that was communicated to generations of biology students as fact). What Stephen Jay Gould described in 1980 as "the most sophisticated of modern American textbooks for introductory biology" endorsed the synthetic theory on the basis of fossil evidence:

[Can] more extensive evolutionary change, macroevolution, be explained as an outcome of these microevolutionary shifts? Did birds really arise from reptiles by an accumulation of gene substitutions of the kind illustrated by the raspberry eye-color gene?

The answer is that it is entirely plausible, and no one has come up with a better explanation. . . . The fossil record suggests that macroevolution is indeed gradual, paced at a rate that leads to the conclusion that it is based on hundreds or thousands of gene substitutions no different in kind from the ones examined in our case histories.

But that last sentence is false, and has long been known to paleontologists to be false.

The fossil record was revisited in the 1970s in works by Stephen Jay Gould, Niles Eldredge, and Steven Stanley. Gould and Eldredge proposed a new theory they called "punctuated equilibrium" ("punk eek" to the irreverent), to deal with an embarrassing fact: the fossil record today on the whole looks very much as it did in 1859, despite the fact that an enormous amount of fossil hunting has gone on in the intervening years. In the words of Gould:

The history of most fossil species includes two features particularly inconsistent with gradualism:

1. Stasis. Most species exhibit no directional change during their tenure on earth. They appear in the fossil record looking pretty much the same as when they disappear; morphological change is usually limited and directionless.
2. Sudden appearance. In any local area, a species does not arise gradually by the steady transformation of its ancestors; it appears all at once and "fully formed."

In short, if evolution means the gradual change of one kind of organism into another kind, the outstanding characteristic of the fossil record is the absence of evidence for evolution. Darwinists can always explain away the sudden appearance of new species by say-

ing that the transitional intermediates were for some reason not fossilized. But stasis—the consistent absence of fundamental directional change—is positively documented. It is also the norm and not the exception.

According to Steven Stanley, the Bighorn Basin in Wyoming contains a continuous local record of fossil deposits for about five million years, during an early period in the age of mammals. Because this record is so complete, paleontologists assumed that certain populations of the basin could be linked together to illustrate continuous evolution. On the contrary, species that were once thought to have turned into others turn out to overlap in time with their alleged descendants, and "the fossil record does not convincingly document a single transition from one species to another." In addition, species remain fundamentally unchanged for an average of more than one million years before disappearing for an average of more than one million years before disappearing from the record. Stanley uses the example of the bat and the whale, which are supposed to have evolved from a common mammalian ancestor in little more than ten million years, to illustrate the insuperable problem that fossil stasis poses for Darwinian gradualism:

Let us suppose that we wish, hypothetically, to form a bat or a whale . . . [by a] process of gradual transformation of established species. If an average chronospecies lasts nearly a million years, or even longer, and we have at our disposal only ten million years, then we have only ten or fifteen chronospecies¹ to align, end-to-end, to form a continuous lineage connecting our primitive little mammal with a bat or a whale. This is clearly preposterous. Chronospecies, by definition, grade into each other, and each one encompasses very little change. A chain of ten or fifteen of these might move us from one small rodentlike form to a slightly different one, perhaps representing a new genus, but not to a bat or a whale!

To provide more rapid change Stanley relies partly upon the so far untestable theory that random mutations in the "regulatory genes" might alter the program for embryonic development suffi-

¹ In the living world, species are separate reproductive communities, which do not interbreed. Because we cannot determine the breeding capabilities of creatures known only by fossils, these have to be assigned to species by their visible characteristics. A "chronospecies" is a segment of a fossil lineage judged to have evolved so little in observable characteristics that it remained a single species.

included the leading paleontologists and geologists of the day. Darwin's defense of the theory against the fossil evidence was not unreasonable, but the point is, it was a *defense*. Very possibly the fossil beds are mere snapshots of moments in geological time, with sufficient time and space between them for a lot of evolution to be going on in the gaps. Still, it is one thing to say that there are gaps, and quite another thing to claim the right to fill the gaps with the evidence required to support one's theory. Darwin's arguments could establish at most that the fossil problem was not fatal; they could not turn the absence of confirming evidence into an asset.

There was a way to test the theory by fossil evidence, however, if Darwin and his followers had wanted a test. Darwin was emphatic that the number of transitional intermediates must have been immense, even "inconceivable." Perhaps evidence of their existence was missing because in 1859 only a small part of the world's fossil beds had been searched, and because the explorers had not known what to look for. Once paleontologists accepted Darwinism as a working hypothesis, however, and explored many new fossil beds in an effort to confirm the theory, this situation ought to change. In time the fossil record could be expected to look very different, and very much more Darwinian.

The test would not be fair to the skeptics, however, unless it was also possible for the theory to fail. Imagine, for example, that belief in Darwin's theory were to sweep through the scientific world with such irresistible power that it very quickly became an orthodoxy. Suppose that the tide was so irresistible that even the most prestigious of scientists—Harvard's Louis Agassiz, for example—became an instant has-been for failing to join the movement. Suppose that paleontologists became so committed to the new way of thinking that fossil studies were published only if they supported the theory, and were discarded as failures if they showed an absence of evolutionary change. As we shall see, that is what happened. Darwinism apparently passed the fossil test, but only because it was not allowed to fail.

Darwin's theory predicted not merely that fossil transitionals would be found; it implied that a truly complete fossil record would be mostly transitionals, and that what we think of as fixed species would be revealed as mere arbitrary viewpoints in a process of continual change. Darwinism also implied an important prediction

about extinction, that necessary corollary of the struggle for existence. Darwin recognized that his theory required a pattern of extinction even more gradual than the pattern of evolutionary emergence:

The old notion of all the inhabitants of the earth having been swept away at successive periods by catastrophes, is very generally given up, even by those geologists . . . whose general views would naturally lead them to this conclusion. . . . There is reason to believe that the complete extinction of the species of a group is generally a slower process than their production: if the appearance and disappearance of a group of species be represented, as before, by a vertical line of varying thickness, the line is found to taper more gradually at its upper end, which marks the progress of extermination, than in its lower end, which marks the first appearance and increase in numbers of the species. In some cases, however, the extermination of whole groups of beings, as of ammonites towards the close of the secondary period, has been wonderfully sudden.

Continual, gradual extinctions are a necessary consequence of the assumption that ancestor species are constantly being supplanted by better adapted descendants. Suppose, however, that it were shown that a substantial proportion of extinctions have occurred in the course of a few global catastrophes, such as might be caused by a comet hitting the earth or some sudden change in temperature. In such catastrophes survival would not necessarily have been related to fitness in more normal circumstances, and might have been entirely at random. Darwinism could therefore be tested not only by searching for transitional species in newly discovered fossil beds, but also by studying the pattern of extinctions to measure the importance of catastrophes.

Evolution triumphed during Darwin's lifetime, although his opposition to saltations remained controversial in scientific circles for a long time to come. The discovery of *Archaeopteryx*—an ancient bird with some strikingly reptilian features—was enough fossil confirmation in itself to satisfy many. Thereafter it was one apparent fossil success after another, with reports of human ancestors, ancient mammal-like reptiles, a good sequence in the horse line, and so on. Paleontology joined the neo-Darwinian synthesis in the work of George Gaylord Simpson, who declared that Darwin had been

of Lyell's logic, but Lyell himself had great difficulty accepting biological evolution, as did many other persons who were familiar with the evidence.

Each of the divisions of the biological world (kingdoms, phyla, classes, orders), it was noted, conformed to a basic structural plan, with very few intermediate types. Where were the links between these discontinuous groups? The absence of transitional intermediates was troubling even to Darwin's loyal supporter T. H. Huxley, who warned Darwin repeatedly in private that a theory consistent with the evidence would have to allow for some big jumps.

Darwin posed the question himself, asking

why, if species have descended from other species by insensibly fine gradations, do we not everywhere see innumerable transitional forms? Why is not all nature in confusion instead of the species being, as we see them, well defined?

He answered with a theory of extinction which was the logical counterpart of "the survival of the fittest." The appearance of an improved form implies a disadvantage for its parent form. Thus, "if we look at each species as descended from some other unknown form, both the parent and all the transitional varieties will generally have been exterminated by the very process of formation and perfection of the new form." This extermination-by-obsolescence implies that *appearances* will be against a theory of evolution in our living world, because we see distinct, stable species (and larger groupings), with only rare intermediate forms. The links between the discontinuous groups that once existed have vanished due to maladaptation.

But what if the necessary links are missing not only from the world of the present, but from the fossil record of the past as well? Darwin acknowledged that his theory implied that "the number of intermediate and transitional links, between all living and extinct species, must have been inconceivably great." One might therefore suppose that geologists would be continually uncovering fossil evidence of transitional forms. This, however, was clearly not the case. What geologists did discover was species, and groups of species, which appeared suddenly rather than at the end of a chain of evolutionary links. Darwin conceded that the state of the fossil

evidence was "the most obvious and gravest objection which can be urged against my theory," and that it accounted for the fact that "all the most eminent paleontologists . . . and all our greatest geologists . . . have unanimously, often vehemently, maintained the immutability of species."

Darwin argued eloquently that the fossil problem, although concededly serious, was not fatal to his theory. His main point was that the fossil record is extremely imperfect. Fossils are preserved only in special circumstances, and thus the various fossil beds of the world probably reflect not a continuous record but rather pictures of relatively brief periods separated from each other by wide intervals of time. Additionally, we might fail to recognize ancestor-descendant relationships in the fossils even if they were present. Unless we had all the intervening links to show the connections between them, the two forms might appear entirely distinct to our eyes. At times Darwin even seemed to be implying that the absence of transitionals was itself a proof of the inadequacy of the record, as it would be if one had *a priori* knowledge that his theory was true:

I do not pretend that I should ever have suspected how poor a record of the mutations of life, the best preserved geological section presented, had not the difficulty of our not discovering innumerable transitional links between the species which appeared at the commencement and close of each formation, pressed so hardly on my theory.

Darwin did as well with the fossil problem as the discouraging facts allowed, but to some questions he had to respond frankly that "I can give no satisfactory answer," and there is a hint of desperation in his writing at times, as in the following sentence: "Nature may almost be said to have guarded against the frequent discovery of her transitional or linking forms." But Darwin never lost faith in his theory; the only puzzle was how to account for the plainly misleading aspects of the fossil record.

At this point I ask the reader to stop with me for a moment and consider what an unbiased person ought to have thought about the controversy over evolution in the period immediately following the publication of *The Origin of Species*. Opposition to Darwin's theory could hardly be attributed to religious prejudice when the skeptics

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