4. Hume formulated a principle that states how the strength of an analogy argument may be measured. What is it?
5. What two criticisms did Hume make of the design argument? Are these good criticisms if the argument is understood to be abductive in character?

Problems for Further Thought

1. It might be suggested that one difference between Paley's argument about the watch and his argument about organisms is that we have seen watchmakers, but have never directly observed God. Does this point of difference undermine the force of Paley's design argument?
2. I mentioned in passing that modern science no longer takes seriously the idea that *all* things are goal-directed systems. Consider the following pair of propositions. Can you think of a reason that the first of them might be true, whereas the second might be rejected?

   The function of the heart is to pump blood.

   The function of rain is to provide farm crops with water.

   What does it mean to attribute a "function" to something?
3. In addition to the two criticisms that Hume makes of the design argument that are described in this chapter, Hume presents a third. He says that even if the design argument succeeds in showing that a designer made the universe (or the organisms in it), the argument does not succeed in establishing what characteristics that designer has. For this reason, the argument does not show that God exists. Is Hume's claim correct? How seriously does this undermine the design argument?

CHAPTER 6

Evolution and Creationism

Aquinas and Paley maintained that the intricacy and adaptedness of organisms can be explained only by viewing them as the product of intelligent design, but they were not able to consider an alternative theory that Charles Darwin (1809–1882) put on the table in 1859 when he published his book *The Origin of Species.* Modern-day creationists do consider what their predecessors could not; they reject Darwin's theory and maintain that the old design argument is still correct. My goal in this chapter is to give a sample of the kinds of arguments that one needs to consider in thinking about the evolution versus creation debate. As I promised at the end of Chapter 3, I'll here introduce a new principle that is important to abductive inference, which will supplement the Surprise Principle and the Only Game in Town Fallacy. Unfortunately, I won't have time to provide a full treatment of the philosophical issues, and there are lots of biological details that are important here that I won't be able to discuss.

CREATIONISM

Creationists (sometimes calling themselves "scientific creationists" or "intelligent design theorists") are present-day defenders of the design argument. Although they agree among themselves that intelligent design is needed to explain some features of the living world, they disagree with each other about various points of detail. Some hold that the earth is young (around 10,000 years old), whereas others concede that it is ancient—about 4.5 billion years old, according to current geology. Some creationists maintain that each species (or basic "kind" of organism) was separately created by an intelligent designer, whereas others concede that biologists are right when they assert, as Darwin did, that all life on earth traces back to a common ancestor.

To clarify what creationism asserts, let's consider three possible relationships that might obtain among God (G), mindless evolutionary processes (E), and the complex adaptations that organisms are observed to have (O):

(theistic evolutionism) $G \longrightarrow E \longrightarrow O$

(atheistic evolutionism) $E \longrightarrow O$

(creationism)
$$\begin{tikzcd} G \arrow[r] \arrow[rr, bend right] & E \arrow[r, "/" marking] & O \end{tikzcd}$$

Theistic evolutionism says that God set mindless evolutionary processes in motion; these processes, once underway, suffice to explain the complex adaptations we observe organisms to have. Atheistic evolutionism denies that there is a God, but otherwise agrees with theistic evolutionism that mindless evolutionary processes are responsible for complex adaptations. Creationism disagrees with both theistic evolutionism and atheistic evolutionism. Creationism maintains that mindless evolutionary processes are incapable of giving rise to complex adaptations and that God directly intervenes in nature to bring these about. Creationism does not deny that evolution is responsible for some of the features we observe in nature; creationists concede that quantitative changes in a feature found in a species might be due to natural selection (an example of this sort of change will be described below). However, the emergence of genuinely novel, complex adaptive features is, for creationists, another story entirely.

You can see from these three options that belief in evolutionary theory is not the same as atheism. In my opinion, current evolutionary theory is neutral on the question of whether there is a God. Evolutionary theory can be supplemented with a claim, either *pro* or *con*, concerning whether God exists. Evolutionary theory also is consistent with agnosticism, which is the view that we don't know whether there is a God.

Evolutionary theory, however, is not consistent with creationism. Evolutionary theory holds that mindless evolutionary processes (including the process of natural selection) are responsible for the complex adaptations we observe; creationism denies this.

SOME CREATIONIST ARGUMENTS

Some of the most frequently repeated creationist arguments contain mistakes and confusions. For example, some creationists have argued that evolutionary theory is on shaky ground because hypotheses about the distant past can't be proven with absolute certainty. They are right that evolutionary theory isn't absolutely certain, but then nothing in science is absolutely certain; recall the remarks in Chapter 3 about gambling. What one legitimately strives for in science is powerful evidence showing that one explanation is far more plausible than its competitors. Biologists now regard the hypotheses of evolution as about as certain as any hypothesis about the prehistoric past could be. Naturally, no scientist was on the scene some 3.8 billion years ago when life started to exist on Earth. However, it is nonetheless possible to have strong evidence about matters that one can't directly observe, as I hope my previous discussion of abduction has made clear.

Another example of an error that some creationists make is their discussion of the Second Law of Thermodynamics. They claim this law shows that it is impossible for order to arise from disorder by natural processes. Natural processes can lead an automobile to disintegrate into a junk heap, but creationists think the Second Law of Thermodynamics says that no natural process can cause a pile of junk to assemble itself into a functioning car. Here creationists are arguing that physics is inconsistent with the claim that life evolved from nonlife. What the Second Law actually says is that a *closed system* will (with high probability) move from states of greater order to states of lesser order. But if the system isn't closed, the law says nothing about what will happen. So if the Earth were a closed system, its overall level of disorder would have to increase. But, of course, the Earth is no such thing—energy from the sun is a constant input. If the universe as a whole as a closed system, then thermodynamics does entail that disorder will increase overall. But this overall trend doesn't prohibit "pockets" of order from arising and being maintained. The Second Law of Thermodynamics offers no basis for thinking that life couldn't have evolved from nonlife.

A full treatment of the evolution versus creationism debate would require me to describe the positive explanations that creationists have advanced. If you want to compare evolutionary theory and creationism, you can't just focus on whatever difficulties there may be in evolutionary ideas. You've also got to look carefully at what the alternative is. Doing this produces lots of difficulties for creationism. The reason is that creationists have either been woefully silent on the details of the explanation they want to defend, or they have produced detailed stories that can't withstand scientific scrutiny. For example, young earth creationists, as I mentioned, maintain that the earth is only a few thousand years old. This claim conflicts with a variety of very solid scientific findings, from geology and physics. It isn't just evolutionary theory that you have to reject if you buy into this version of creationism, but a good deal of the rest of science as well.

As I also indicated, there are many different versions of creationism. Creationism is not a single theory, but a cluster of similar theories. In the present chapter, I won't attempt to cover all these versions, but will focus on a few of the options. First let's look at the ABCs of Darwinism.

DARWIN'S TWO-PART THEORY

Many of the main ideas that Darwin developed in *The Origin of Species* are still regarded by scientists as correct, but others have been refined or expanded. Still others have been junked entirely. Although evolutionary theory has developed a long way since Darwin's time, I'll take his basic ideas as a point of departure. Darwin's theory contains two main elements. First, there is the idea that all present-day life is related. The organisms we see didn't come into existence independently by separate creation. Rather, organisms are related to each other by a family tree. You and I are related. If we go back far enough in time, we'll find a human being who is an ancestor of both of us. The same is true of us and a chimp, though, of course, we must go back even further in time to reach a common ancestor. And so it is for any two present-day organisms. Life evolved from nonlife, and then descent with modification gave rise to the diversity we now observe.

Notice that this first hypothesis of Darwin's says nothing about *why* new characteristics arose in the course of evolution. If all life is related, why aren't all living things identical? The second part of Darwin's theory is the idea of natural selection. This hypothesis tries to explain why new characteristics appear and become common and why some old characteristics disappear. It is very important to keep these two elements in Darwin's theory separate. The idea that all present-day living things are related isn't at all controversial in modern science. The idea that natural selection is the principal cause of evolutionary change is *somewhat* controversial, although it is still by far the majority view among biologists. One reason it is important to keep these ideas separate is that some creationists have tried to score points by confusing them. Creationists sometimes suggest that the whole idea of evolution is something even biologists regard with great doubt and suspicion. However, the idea that all life is related isn't at all controversial. What is controversial, at least to some degree, are ideas about natural selection.

NATURAL SELECTION

Here's a simple example of how natural selection works. Imagine a population of zebras that all have the same top speed. They can't run faster than 38 mph. Now imagine that a novelty appears in the population. A mutation occurs—a change in the genes found in some zebra—that allows that newfangled zebra to run faster at 42 mph, say. Suppose running faster is advantageous, because a fast zebra is less likely to be caught and eaten by a predator than a slow one is. Running fast enhances the organism's *fitness*—its ability to survive and reproduce. If running speed is passed on from parent to offspring, what will happen? What will occur (probably) is that the fast zebra will have more offspring than the average slow zebra. As a result, the percentage of fast zebras increases. In the next generation, fast zebras enjoy the same advantage, and so the characteristic of being fast will again increase in frequency. After a number of generations, we expect all the zebras to have this new characteristic. Initially, all the zebras ran at 38 mph. After the selection process runs its course, all run at 42 mph. So the process comes in two stages. First, a novel mutation occurs, creating the variation upon which natural selection operates. Then, natural selection goes to work changing the composition of the population:

Start →	*Then* →	*Finish*
100% run at 38 mph.	A novel mutant runs at 42 mph; the rest run at 38 mph.	100% run at 42 mph.

We may summarize how this process works by saying that natural selection occurs in a population of organisms when there is *inherited variation in fitness*. Let's analyze what this means. The organisms must *vary;* if all the organisms are the same, then there will be no variants to select among. What is more, the variations must be passed down from parents to offspring. This is the requirement of *inheritance*. Last, it must be true that the varying characteristics in a population affect an organism's *fitness*—its chance of surviving and reproducing. If these three conditions are met, the population will evolve. By this, I mean that the frequency of characteristics will change.

The idea of natural selection is really quite simple. What Darwin did was to show how this simple idea has many implications and applications. Merely stating this simple idea wouldn't have convinced anyone that natural selection is the right explanation of life's diversity. The power of the idea comes from the numerous detailed applications.

Notice that the introduction of novel characteristics into a population is a precondition for natural selection to occur. Darwin didn't have a very accurate picture of how novel traits arise. He theorized about this, but didn't come up with anything of lasting importance. Rather, it was later in the nineteenth century that Mendel started to fill in this detail. Genetic mutations, we now understand, are the source of the variation on which natural selection depends. One central idea that Darwin had about mutation, which twentieth-century genetics has vindicated, is that mutations do not occur because they would be useful to the organism; this is what biologists mean when they say that mutations occur "at random."

Creationists sometimes say that the process of evolution by natural selection is like a tornado blowing through a junkyard. The latter process cannot sweep together the scraps of metal laying around on the ground and assemble them into a functioning automobile. From this, creationists conclude that the former process is likewise incapable of creating novel adaptations. This analogy is fundamentally misleading. The tornado is a totally random process, like the spinning of a huge roulette wheel.

However, evolution by natural selection has two parts; mutations appear randomly, but then it is not a random matter which mutations increase in frequency and which decline. Selection is nonrandom. A better analogy than the tornado in the junkyard is one that Darwin proposed in his 1873 book *The Variation of Animals and Plants Under Domestication:*

> Let an architect be compelled to build an edifice with uncut stones, fallen from a precipice. The shape of each fragment may be called accidental; yet the shape of each has been determined by the force of gravity, the nature of the rock, and the slope of the precipice,—events and circumstances all of which depend on natural laws; but there is no relation between these laws and the purpose for which each fragment is used by the builder. In the same manner the variations of each creature are determined by fixed and immutable laws; but these bear no relation to the living structure which is slowly built up through the power of natural selection, whether this be natural or artificial selection. (Darwin 1876, p. 236)

Notice that the little story I've told about zebra running speed describes a rather modest change that occurs *within* an existing species. Yet Darwin's 1859 book was called *The Origin of Species.* How does change within a species help explain the coming into existence of new species?

SPECIATION

Darwin's hypothesis was that small changes in a population (like the one I just described) add up. Given enough little changes, the organisms will become very different. Modern evolutionists usually tell a story like the following one. Think of a single population of zebras. Imagine that a small number of zebras are separated from the rest of the population for some reason; maybe they wander off or a river changes course and splits the old population in two. If the resulting populations live in different environments, selection will lead them to become increasingly different. Characteristics that are advantageous in one population will not be advantageous in the other. After a long time, the populations will have diverged. They will have become so different from each other that individuals from the one can't breed with individuals from the other. Because of this, they will be two species, not two populations belonging to the same species.

Pretty much everybody in Darwin's day, including those who thought that God created each species separately, would have agreed that the little story about zebras evolving a greater speed could be true. The real resistance to Darwin's theory focused on his thesis that the mechanism responsible for small-scale changes *within* species also gives rise to large-scale changes, namely, to the origin of *new* species. This was a daring hypothesis, but it now is the mainstream view in evolutionary theory. Even so, biologists continue to debate the importance that natural selection has had in the evolutionary process. Modern evolutoinary theory describes other possible causes of evolutionary change. Which traits were due to natural selection and which were due to other evolutionary processes? There are a number of still unanswered questions in evolutionary biology about natural selection. Even biologists who hold that natural selection is the major cause of evolution are sometimes puzzled about how it applies in particular cases. For example, it is still rather unclear why sexual reproduction evolved. Some creatures reproduce sexually, others asexually. Why is this? Although there are open questions pertaining to natural selection, I want to emphasize that it isn't at all controversial that human beings share common ancestors with chimps. Don't confuse the idea of common ancestry with the idea of natural selection; these are separate elements in Darwin's theory.

THE TREE OF LIFE

I turn now to this uncontroversial idea. Why do biologists think it is so clear that living things are related to each other—that there is a family tree of life on earth just like there is a family tree of your family? Two kinds of evidence have seemed persuasive. I won't give the details here; rather, I want to describe the *kinds* of arguments biologists deploy. As a philosopher, I'm more interested that you grasp the logic of the arguments; for the biological details, you should consult a biology book.

To illustrate how one line of argument works, consider this simple problem. Suppose I assign a philosophy class the job of writing an essay on the meaning of life. As I read through the papers, I notice that two students have handed in papers that are word-for-word identical. How should I explain this striking similarity? One possibility, of course, is that the students worked independently and by coincidence arrived at exactly the same result. The independent origin of the two papers isn't impossible. But I would regard this hypothesis as extremely implausible. Far more convincing is the idea that one student copied from the other or that each of them copied from a common source—a paper downloaded from the Internet, perhaps. This hypothesis is a more plausible explanation of the observed similarity of the two papers.

THE PRINCIPLE OF THE COMMON CAUSE

The plagiarism example illustrates an idea that the philosopher Hans Reichenbach (in *The Direction of Time,* University of California Press, 1956) called the *Principle of the Common Cause.* Let's analyze the example more carefully to understand the rationale of the principle.

Why, in the case just described, is it more plausible that the students copied from a common source than that they wrote their papers independently? Consider how probable the matching of the two papers is, according to each of the two hypotheses. If the two students copied from a common source, then it is rather probable that the papers should closely resemble each other. If, however, the students worked independently, then it is enormously improbable that the two papers should be so similar. Here we have an application of the Surprise Principle described in Chapter 3: If one hypothesis says that the observations are very probable whereas the other hypothesis says that the observations are very improbable, then the observations strongly favor the first hypothesis over the second. The Principle of the Common Cause makes sense because it is a consequence of the Surprise Principle.

The example just described involves hypotheses that describe mental activity—when students plagiarize they use their minds, and the same is true when they write papers independently. However, it is important to see that the Principle of the Common Cause also makes excellent sense when the hypotheses considered do not describe mental processes. Here's an example: I have a barometer at my house. I notice that when it says "low," there usually is a storm the next day; and when it says "high," there usually is no storm the next day. The barometer reading on one day and the weather on the next are *correlated.* It may be that this correlation is just a coincidence; perhaps the two events are entirely independent. However, a far more plausible hypothesis is that the reading on one day and the weather on the next trace back to a common cause—namely, the weather at the time the reading is taken:

$$\begin{tikzcd} \text{barometer reading today} & & \text{weather tomorrow} \\ & \text{today's weather} \arrow[ul] \arrow[ur] & \end{tikzcd}$$

The common cause hypothesis is more plausible because it leads you to expect the correlation of the two observed effects. The separate cause hypothesis is less plausible because it says that the observed correlation is a very improbable coincidence. Notice that the hypotheses in this example do not describe the mental activities of agents.

ARBITRARY SIMILARITIES AMONG ORGANISMS

I'll now apply this principle to the evolutionary idea of common ancestry. One reason biologists think all life is related is that all organisms (with some minor exceptions) use the same genetic code. To understand what this means, think of the genes in your body as a set of instructions for constructing more complex biological items—amino acids and then proteins. The total sequence of genes in your body and the sequence in a frog's are different. The striking fact, however, is that the gene that codes for a given amino acid in a frog codes for that very same amino acid in people. As far as we now know, there is no reason why the genes that code for a given amino acid had to code for that acid rather than some other. The code is arbitrary; there is no functional reason why it has to be the way it is. (Don't be misled by my talk of codes here. This word may suggest intelligent design, but this isn't what biologists mean. Genes *cause* amino acids to form; for present purposes, this is a perfectly satisfactory way to understand what it means for genes to "code for" this or that amino acid.)

How are we to explain the detailed similarity among the genetic codes that different species use? If the species arose independently of each other, we would expect them to use different genetic codes. But if those species all trace back to a common ancestor, it is to be expected that they will share the same genetic code. The Principle of the Common Cause underlies the belief that evolutionary biologists have that all living things on earth have common ancestors.

USEFUL SIMILARITIES AMONG ORGANISMS

The reason a shared genetic code is evidence of common ancestry is that the code is arbitrary. There are lots of possible codes that would work. If there were only a single functional code, the fact that different species use this one code would not be evidence of common ancestry. Consider, for example the fact that sharks and dolphins both have a streamlined body shape. Both are shaped like torpedoes. Is this strong evidence that they have a common ancestor? I would say not. There is an obvious functional reason why large predators that spend their lives swimming through water should be shaped like this. If there is life in other galaxies that includes large aquatic predators, we would probably expect it to have this sort of shape. Even if life on earth and life on other galaxies are not descended from common ancestors, there are *some* similarities we still would expect to find. I conclude that the streamlined shape of dolphins and sharks isn't strong evidence that they evolved from a common ancestor. The Surprise Principle explains why some similarities, but not others, are evidence for the hypothesis that there is a tree of life uniting all organisms on earth.

The genetic code is one just one example of a similarity that can't be explained by its usefulness to the organism. There are lots of others. Consider the fact that human beings have tail bones, that we have appendices, and that human fetuses have gill slits. None of these features is useful. In fact, the appendix is worse than useless, since burst appendices kill many people. Biologists interpret these features as evidence that we share common ancestors with nonhuman organism. This and lots of other evidence points to the conclusion that we share common ancestors with monkeys, with other mammals, with fish, and with all other living things. In drawing this conclusion, biologists are using the Surprise Principle and the Principle of the Common Cause.

IRREDUCIBLE COMPLEXITY

Although creationists have usually rejected the Darwinian hypothesis of common ancestry, not all have done so. What creationists universally reject is the thesis that natural selection is the correct explanation of the complex adaptations we observe in nature. Modern-day creationists are usually willing to grant that selection can explain small modifications in existing species, as in the earlier example about zebra running speed. But how can the gradual accumulation of modifications explain a feature like the vertebrate eye? This is the key objection that Michael Behe develops in

Humans from Nonhumans, Life from Nonlife

When people hear about the idea of evolution, there are two parts of the theory that sometimes strike them as puzzling. First, there is the idea that human beings are descended from apelike ancestors. Second, there is the idea that life evolved from nonliving materials.

Scientists believe the first of these statements because there are so many striking similarities between apes and human beings. This isn't to deny that there are differences. However, the similarities (e.g., the fact that both have tail bones) would be expected if humans and apes have a common ancestor, but would be quite surprising if they came into existence independently..

There is a big difference between having evidence humans are descended from apelike ancestors and *having an explanation of precisely why this happened.* The evidence for a common ancestor is pretty overwhelming, but the details of why evolution proceeded in just the way it did are less certain. Students of human evolution continue to investigate why our species evolved as it did. In contrast, the claim that we did evolve isn't a matter of scientific debate.

What about the second idea—that life arose from nonlife? Why not maintain that God created the first living thing and then let evolution by natural selection produce the diversity we now observe? Notice that this is a very different idea from what creationists maintain. They hold that each species (or "basic kind" of organism) is the result of separate creation by God. They deny that present-day species are united by common descent from earlier life forms.

One main sort of evidence for thinking that life evolved from nonlife on Earth about 4 billion years ago comes from laboratory experiments. Scientists have created laboratory conditions that resemble the ones they believe were present shortly after the Earth came into existence about 4.5 billion years ago. They find that the nonliving ingredients present then can enter into chemical reactions, the products of which are simple organic materials. For example, it is possible to run electricity (lightning) through a "soup" of inorganic molecules and produce amino acids. Why is this significant? Amino acids are an essential stage in the process whereby genes construct an organism. Similar experiments have generated a variety of promising results. This subject in biology—*prebiotic evolution*—is very much open and incomplete. No one has yet been able to get inorganic materials to produce DNA, but the promising successes to date suggest that further work will further illuminate how life arose from nonlife.

Laboratory experiments don't aim to create a multicellular organism from inorganic materials. No one wants to make a chicken out of carbon, ammonia, and water. Evolution by natural selection proceeds by the accumulation of very small changes. So the transition from nonlife to life must involve the creation of a rather simple self-replicating molecule. Chickens came much later.

A self-replicating molecule is a molecule that makes copies of itself. A molecule of this sort is able to reproduce. With accurate replication, the offspring of a molecule will resemble its parent. Once a simple self-replicating molecule is in place, evolution by natural selection can begin. It may sound strange to describe a simple self-replicating molecule as being "alive." Such a molecule will do few of the things that a chicken does. But from the biological point of view, reproduction and heredity (that is, similarity between parents and offspring) are fundamental properties.

his 1966 book *Darwin's Black Box* when he introduces the concept of *irreducible complexity*. Behe defines an irreducibly complex system as one in which the whole system has a function, the system is made of many parts, and the system would not be able to perform its function if any of the parts were removed. Behe's idea is that the Darwinian process of natural selection involves adding one small part to another, with each modification improving the fitness of the organism. But what good is 1% of an eye? Creationists, Behe included, think that the answer is obvious—no good at all—and that this shows that evolutionary theory can't explain complex adaptations.

Biologists sometimes respond to this creationist claim by arguing that gradual modification *can* explain structures like the eye. A piece of light sensitive skin allows the organism to tell the difference between light and dark, and this is advantageous. Then, if this skin is shaped into a cup, the organism can not only tell whether it is light or dark, but can also tell from what direction the light is coming, and this provides a further advantage. Maybe it is not so obvious that the eye can't evolve one small step at the time. However, there is another, more fundamental, problem with Behe's argument. What we call "the parts" of a system may or may not correspond to the historical sequence of accumulating details. Consider the horse and its four legs. A horse with zero, one, or two legs cannot walk or run; suppose the same is true for a horse with three. In contrast, a horse with four legs can walk and run, and it thereby gains a fitness advantage. So far so good—the four-legged arrangement satisfies the definition of irreducible complexity. The mistake comes from thinking that horses (or their ancestors) had to evolve their four legs one leg at a time. In fact it's a mistake to think that a separate set of genes controls the development of each leg; rather, there is a single set that controls the development of appendages. A division of a system into parts that entails that the system is irreducibly complex may or may not correspond to the historical sequence of events through which the lineage passed. This point is obvious with respect to the horse's four legs, but needs to be borne in mind when other, less familiar, organic features are considered. What we call the "parts" of the eye may not correspond to the sequence of events that occurred in the eye's evolution.

IS CREATIONISM TESTABLE?

So far I have outlined what Darwin's theory of evolution amounts to, the kind of evidence that biologists take seriously for the claim of common ancestry, and some objections that creationists make to this theory. The question I now want to consider concerns the theory that creationists themselves present. What is it? What predictions does it make? What evidence is there for the theory they present?

Here we need to consider some of the different versions that creationism might take. To get started, let's consider:

> H_1: A superintelligent designer fashioned all the complex adaptations we observe organisms to have so that organisms would be perfectly adapted to their environment.

This hypothesis is disconfirmed by what we observe. Organisms often have highly imperfect adaptations. The eye that human beings use has a blindspot, though the eye of the octopus does not. And many spiders have eyes with built-in sunglasses, though human beings do not. Our eye is imperfect and so are lots of features that we and other organisms possess. Can we repair this defect in H_1? One way to do so is to make the hypothesis of intelligent design more modest in what it says:

> H_2: An intelligent designer fashioned all the complex adaptations we observe organisms to have.

The problem with H_2 is not that it makes false predictions, but that it makes none at all. H_2 is consistent with what we observe, no matter what our observations turn out to be. Features that are useful are consistent, as well as features that are neutral and features that are harmful. One of the features that scientists expect scientific theories to have is that they be testable, by which they mean that theories should make predictions that can be checked against observations. H_2, it appears, is not testable. This defect can also be remedied. Consider, for example, a third version of creationism:

> H_3: Organisms did not evolve. Rather, God created each species separately and endowed them with the very characteristics they would have had if they had evolved by natural selection.

H_3 is a wild card; it makes the same predictions that evolutionary theory makes. If so, what reason can there be to choose between these two theories?

PREDICTIVE EQUIVALENCE

Evolutionary theory and H_3 are *predictively equivalent*. If evolutionary theory predicts that life will have a particular feature, so does H_3. Although imperfect adaptations disconfirm H_1, they are perfectly consistent with H_3. Does this mean that evolutionary theory is not well supported? I would say not. Consider the following pair of hypotheses:

> J_1: You are now looking at a printed page.
> J_2: You are now looking at a salami.

You have excellent evidence that J_1 is true and that J_2 is false. J_1 predicts that you are having particular sensory experiences; if J_1 is true, you should be having certain visual, tactile, and gustatory sensations (please take a bite of this page). J_2 makes different predictions about these matters. The sensory experiences you now are having strongly favor J_1 over J_2. Now, however, let's introduce a wild card. What evidence do you have that J_1 *as opposed to* J_3 is true:

> J_3: There is no printed page in front of you, but someone is now systematically misleading you into thinking that there is a printed page in front of you.

J_1 and J_3 are predictively equivalent. The experiences you now are having tell you that J_1 is more plausible than J_2, but they don't strongly favor J_1 over J_3. In the section of this book that focuses on Descartes's *Meditations* (Chapter 13), the problem of choosing between J_1 and J_3 will be examined in detail. For now, what I want you to see is this: When you ask whether some hypothesis is strongly supported by the evidence, you must ask yourself what the alternatives are against which the hypothesis is to be compared. If you compare J_1 with J_2, you'll conclude that J_1 is extremely well supported. However, the problem takes on a different character if you compare J_1 with J_3. The point applies to the competition between evolutionary theory and creationism. When you compare evolutionary theory with creatoinism, everything depends on which version of creationism you consider. Some versions make false predictions, some make no predictions, and some "piggy-back" on evolutionary theory, relying on that theory's ability to make predictions and then using those predictions.

PREDICTION VERSUS ACCOMMODATION

Here a fourth version of creationism raises interesting questions. Suppose we examine the human eye in detail and observe that has a set of features that we'll call F. We then can construct the following version of creationism:

> H_4: An intelligent designer made the human eye and gave it the set of features F.

Does H_4 make predictions? Well, it entails what we should observe. In fact, no theory can do a better job than H_4 does of fitting what we observe, since H_4 hits the nail precisely on the head. The problem is that H_4 merely accomodates the observations; it does not provide novel predictions. It is easy—too easy—to construct hypotheses such as H_4. Whenever you observe that O is true, you just construct the hypothesis that "an intelligent designer wanted O to be true and had the means to bring this about." If such hypotheses were satisfactory, there would be no need to do real science; we could shut down all of the costly research now underway and just invoke this tidy formula.

This suggests that we should supplement the two rules for abduction presented in Chapter 3. In addition to the Surprise Principle and the Only Game in Town Fallacy, we should require that a good theory make predictions that were not used in the construction of that theory. This is the requirement that theories shouldn't merely accommodate what we observe after the fact; in addition, they should make some predictions that are novel.

DOES EVOLUTIONARY THEORY MAKE NOVEL PREDICTIONS?

What is sauce for the goose is sauce for the gander. If we demand that creatonism make novel predictions, we should demand that evolutionary theory do the same. By prediction, I do not restrict myself to saying what will happen in the future. A prediction can involve observations that have not yet been made that reflect events that took place in the past. For example, the part of evolutionary theory that says that organisms possess common ancestors predicts that we should find intermediate fossil forms. Biology says that whales and cows have a common ancestor, so there should be fossils that have characteristics that are "in between." And if birds and dinosaurs have a common ancestor, there should be fossils that are intermediate here as well. Darwin worried about "the incompleteness of the fossil record," but there have been numerous fossil finds that fulfill the predictions of the hypothesis of common ancestry.

What about the other part of Darwin's theory, the hypothesis of natural selection? What does it predict? Here it is important to realize that there are many detailed theories in evolutionary theory that predict which traits will be favored by natural selection in which circumstances. For example, in human beings, slightly more boys than girls are born. In other species, there is extreme male bias, or a female bias, in the sex ratio at birth. Evolutionary theory provides theories that predict when a species should evolve one sex ratio and when it should evolve another. Another example concerns the nature of infectious disease. Suppose you are infected with a disease that is spread through the air; if you get sick, you will take to your bed and you will spread the disease less frequently. Compare this to a disease like diarrhea that is spread through feces. Even if you take to your bed, your feces will be taken from your room and sent into the environment, just as if you were well. Now think about these two patterns from the point of view of the organism that causes the disease. In the case of an airborne disease, selection favors infections that are mild over ones that are severe; in the case of a waterborne disease, selection favors just the opposite pattern. The *vector* of the disease—the details concerning how the disease is spread from infected to uninfected individuals—allows biologists to predict what traits the disease should evolve. These evolutionary ideas have recently been important in biological thinking about AIDS-HIV; see Paul Ewald's *The Evolution of Infectious Disease*, Oxford University Press, 1993, for discussion.

When I say that evolutionary theory makes predictions, I do not mean that it now is in a position to predict the whole detailed future of the planet's biosphere, nor that every detail of the past can be predicted either. There are many open questions in evolutionary, as in any science. However, the theory has made impressive strides since 1859. The same is not true of creationism. Paley compared the random hypothesis with the hypothesis of intelligent design and argued that the latter was better supported; Behe compares evolutionary theory to the hypothesis of intelligent design and draws the same conclusion. In the two hundred years between these two publications, no theory worthy of the name has been developed.

CONCLUDING REMARKS

Creationism comes in many forms. Some of them make very definite predictions about what we observe. The version that says that God made organisms so that they are perfectly adapted to their environments makes predictions that do not accord with what we observe. Young earth creationism, which says that the earth is ten thousand years old, also makes predictions that conflict with what scientists observe. A third version of creationism says that God made organisms to look exactly as they would if they had evolved by the mindless process of natural selection; this makes the same predictions that evolutionary theory makes, and so our observations do not allow us to discriminate between evolutionary theory and this "mimicking" or "piggy-backing" version of creationism. Finally, the bare, minimalistic version of creationism that says that God had some (unspecified) impact on the traits of living things is, I suggest, untestable. We have not found a version of creationism that makes definite predictions about what we observe *and* that is better supported by the observations than evolutionary theory is. What is wanted here is not just a version of creationism that can accommodate the observations after we have made them, but one that tells us what we will observe before we make those observations. Is there a version of creationism that can do this?

Review Questions

1. What are the two main elements of Darwin's theory?
2. Describe what the Principle of the Common Cause says. How is this principle related to the Surprise Principle? How is it used by biologists to decide whether different species have a common ancestor?
3. The geneticist François Jacob said (in "Evolution and Tinkering," *Science,* Vol. 196, 1977, pp. 1161–1166) that "natural selection does not work as an engineer works. It works like a tinkerer—a tinkerer who does not know exactly what he is going to produce but uses whatever he finds around him." What does Jacob mean here? How is this point relevant to evaluating whether the hypothesis of evolution or the hypothesis of intelligent design is a more plausible explanation of the characteristics of living things?
4. What does it mean to say that two theories are predictively equivalent? Can the design hypothesis be formulated so that the existence of imperfect adaptations isn't evidence against it?

Problems for Further Thought

1. Louis Pasteur (1822–1895) developed scientific evidence against the hypothesis of "spontaneous generation." For example, he argued that maggots developing on rotten meat aren't the result of life springing spontaneously from nonliving materials; the maggots were hatched from eggs laid there by their parents. Does Pasteur's discovery mean life couldn't have evolved from nonliving materials?
2. Suppose you are a crew member on the starship *Enterprise,* bound for a new planet. You know there is intelligent life there; the question you want to answer