



LET'S TAKE STOCK OF THE INDUCTIVE TERRAIN TRAVELED THUS FAR. IN CHAPTER 8 WE closely examined the nature and uses of inductive reasoning. We were reminded that a deductive argument, unlike an inductive one, is intended to provide logically conclusive support for its conclusion. If it succeeds in providing such support, it's said to be valid; if not, invalid. If a valid argument has true premises, it's said to be sound. But an inductive argument is intended to supply only probable support for its conclusion. If it manages to provide such support, it's said to be strong; if not, weak. The conclusion of an inductively strong argument is simply more likely to be true than not. If a strong argument has true premises, it's said to be cogent.

We also saw that inductive arguments come in several forms. One of them is enumerative induction, in which we reason from premises about *some* members of a group to a conclusion, or generalization, about the group *as a whole*. All the swans you have ever seen are white, so *all* swans must be white. Forty percent of the students at your college have a driver's license, so 40 percent of all students everywhere must have a driver's license. (Whether these enumerative inductive arguments are strong or cogent is another matter.)

Another kind of inductive argument is argument by analogy (or analogical induction), in which we reason that since two or more things are similar in several respects, they must be similar in some additional respect. In an analogical induction you might argue that (1) since humans can move about, solve mathematical equations, win chess games, and feel pain, *and* (2) since computers (or robots) are like humans in that they can move about, solve mathematical equations, and win chess games, it's therefore probable that computers can also feel pain. Analogical induction, like all inductive reasoning, can establish conclusions only with a degree of probability.

Finally, we saw that causal arguments—inductive arguments whose conclusions contain causal claims—can be enumerative inductions, analogical inductions, or arguments that rely on Mill's methods and similar kinds of inferences.



REVIEW NOTES

A Look Back at the Basics

- **Statement (claim):** An assertion that something is or is not the case
- **Premise:** A statement given in support of another statement
- **Conclusion:** A statement that premises are intended to support
- **Argument:** A group of statements in which some of them (the premises) are intended to support another of them (the conclusion)
- **Indicator words:** Words that frequently accompany arguments and signal that a premise or conclusion is present
- **Deductive argument:** An argument intended to provide conclusive support for its conclusion
- **Inductive argument:** An argument intended to provide probable support for its conclusion



Reasoning well about causal connections means avoiding numerous common errors, including misidentifying or overlooking relevant factors, confusing coincidence with cause, and committing the post hoc fallacy.

We noted only in passing that there is another kind of inductive reasoning that is so important that a whole section in this text (Part 4) is devoted to it: **inference to the best explanation**. Well, here we are in Part 4, and it's time to delve deep into this kind of inductive reasoning, perhaps the most commonly used form of inference and arguably the most empowering in daily life.

Explanations and Inference

Recall from Chapter 1 that an explanation is a statement (or statements) asserting why or how something is the case. For example: The bucket leaks because there's a hole in it. He was sad because his dog died. She broke the pipe by hitting it with a wrench. These explanations and all others are intended to clarify and elucidate, to increase our understanding. Remember too our discussion of the important distinction between an explanation and an argument. While an explanation tells us *why or how something is the case*, an argument gives us reasons for believing *that something is the case*.

As you've probably already guessed, there are also different kinds of explanations. (See the box "The Lore of Explanations.") For instance, some explanations are what we might call procedural—they try to explain how something is done or how an action is carried out. ("She opened up the engine, then examined the valves, then checked the cylinders.") Some are interpretive—they try to explain the meaning of terms or states of affairs. ("This word means 'dashing' or 'jaunty.'") And some are functional—they try to explain how something functions. ("The heart circulates and oxygenates the blood.")

But the kind of explanation we're concerned with here—and the kind we bump into most often—is what we'll call, for lack of something snappier, a **theoretical explanation**. Such explanations are theories, or hypotheses, that try to explain why something is the way it is, why something is the case, why something happened. In this category we must include all explanations intended to explain the cause of events—the causal explanations that are so important to both science and daily life. Theoretical explanations, of course, are claims. They assert that something is or is not the case.

Now, even though an explanation is not an argument, an explanation can be *part* of an argument. It can be the heart of the kind of inductive argument known as inference to the best explanation. And in this kind of inference, the explanations we use are theoretical explanations.

In inference to the best explanation, *we reason from premises about a state of affairs to an explanation for that state of affairs*. The premises are statements about observations or other evidence to be explained. The explanation is a claim about why the state of affairs is the way it is. The key question that this type of inference tries to answer is, What is the best explanation for the existence or nature of this state of affairs? The best explanation is the one most likely to be true, even though there is no guarantee of its truth as there is in deductive inference.

"There is nothing more practical than a good theory."

—Leonid Ilich Brezhnev



Let's look briefly at the other kinds of inductive inferences we have studied. Recall that *enumerative induction* has this pattern:

*X percent of the observed members of group A have property P.
Therefore, X percent of all members of group A probably have property P.*

Remember:

Forty percent of the pickles that you've pulled out of the barrel are exceptionally good. So 40 percent of all the pickles in the barrel are probably exceptionally good.

All of the blue herons that we've examined at many different sites in the nature preserve (about two hundred birds) have had birth defects. Therefore, most of the blue herons in the nature preserve probably have birth defects.

Every Gizmo computer I've bought in the last two years has had a faulty monitor. Therefore all Gizmo computers probably have faulty monitors.

Analogical induction has this pattern:

*Thing A has properties P_1 , P_2 , P_3 plus the property P_4 .
Thing B has properties P_1 , P_2 , and P_3 .
Therefore, thing B probably has property P_4 .*

For example:

Character is the foundation stone upon which one must build to win respect.

Just as no worthy building can be erected on a weak foundation, so no lasting reputation worthy of respect can be built on a weak character. [R. C. Samsel]

As for one who is choosy about what he learns . . . we shall not call him a lover of learning or a philosopher, just as we shall not say that a man who is difficult about his food is hungry or has an appetite for food. We shall not call him a lover of food but a poor eater. . . . But we shall call a philosopher the man who is easily willing to learn every kind of knowledge, gladly turns to learning things, and is insatiable in this respect. [Plato]

Mice are mammals, have a mammalian circulatory system, have typical mammalian biochemical reactions, respond readily to high blood pressure drugs, and experience a reduction in blood cholesterol when given the new Drug Z. Humans are mammals, have a mammalian circulatory system, have typical mammalian biochemical reactions, and respond readily to high blood pressure drugs. Therefore, humans will also experience a reduction in blood cholesterol when given the new Drug Z.

Inference to the best explanation, however, has this pattern:

*Phenomenon Q.
E provides the best explanation for Q.
Therefore, it is probable that E is true.*



For example:

The new quarterback dropped the ball again. The best explanation for that screw-up is that he's nervous. So he's definitely nervous.

The best explanation for Maria's absence today is that she's angry at the boss. Yep, she's mad at the boss.

The defendant's fingerprints were all over the crime scene, the police found the victim's blood on his shirt, and he was in possession of the murder weapon. The only explanation for all this that makes any sense is that the defendant actually committed the crime. He's guilty.

If the explanations in these arguments really are the best, then the arguments are inductively strong. And if the premises are also true, then the arguments are cogent. If cogent, we are justified in believing that the explanations for the phenomena are in fact correct.

Notice that an inference to the best explanation always goes “beyond the evidence”—it tries to explain facts but does so by positing a theory that is not derived entirely from those facts. It tries to understand the known by putting forth—through inference and imagination—a theoretical pattern that encompasses both the known and unknown. It proposes a plausible pattern that expands our understanding.

The fact that there are *best* explanations, of course, implies that not all explanations for a state of affairs are created equal; some are better than others. Just because you've devised an explanation for something doesn't mean that you're justified in believing that the explanation is the right one. If other explanations are just as good, your explanation is in doubt. If other explanations are better than yours, you are not justified in believing it. But much of the time, after further study or thought, you can reasonably conclude that a particular explanation really is the best explanation. (More on how to evaluate the relative worth of explanations later.) In this way you can come to understand the state of affairs more than you did before.

Inference to the best explanation probably seems very familiar to you. That's because you use it all the time—and need it all the time. Often when we try to understand something in the world, we construct explanations for why this something is the way it is, and we try to determine which of these is the best. Devising explanations helps increase our understanding by fitting our experiences and background knowledge into a coherent pattern. At every turn we are confronted with phenomena that we can only fully understand by explaining them.

Sometimes we're barely aware that we're using inference to the best explanation. If we awaken and see that the streets outside are wet, we may immediately posit this explanation: It's been raining. Without thinking much about it, we may also quickly consider whether a better explanation is that a street-sweeper machine has wet the street. Just as quickly we may dismiss this explanation because we see that the houses and cars are also wet. After reasoning in this fashion, we may decide to carry an umbrella that day.



REVIEW NOTES

The Lore of Explanations

An explanation is a statement (or statements) asserting why or how something is the case. In traditional terminology, that which is to be explained in an explanation is called the *explanandum*, and that which does the explaining is called the *explanans*. Take this explanation: “The dog barked because a prowler was nearby.” The explanandum is “the dog barked,” and the explanans is “a prowler was nearby.”

You can categorize explanations in many ways, depending on the kind of explanandum in which you’re interested. Here are a few of the more common categories:

- Teleological explanations try to explain the purpose of something, how it functions, or how it fits into a plan. (*Telos* is a Greek word meaning “end” or “purpose.”)

Example: The wall switch is there so you can turn off the lamp from across the room.

Example: These wildflowers are here as a blessing from God.

- Interpretive explanations concern the meaning of terms or states of affairs. These explanations seek to understand not something’s purpose or cause, but rather its sense or semantic meaning.

Example: When Mary smiled, she was signaling her agreement.

Example: “Effect” means to accomplish, but “affect” means to influence.

- Procedural explanations try to explain how something is done or how an action is carried out.

Example: To stop the chemical reaction, Ariana added sulfur.

Example: He paid his taxes online by downloading the forms, then using his credit card number.

Let’s consider a more elaborate example. Say that you discover that your car won’t start in the morning (the phenomenon to be explained). You would like to know why it won’t start (the explanation for the failure) because you can’t repair the car unless you know what the problem is. You know that there are several possible explanations or theories.

1. The battery is dead.
2. The fuel tank is empty.
3. The starter has malfunctioned.

4. A vandal has sabotaged the car.
5. All or several of the above.

So you try to figure out which theory is the most plausible, that is, most likely to be true. You see right away that there is snow around the car from yesterday's snowstorm—but there are no tracks (not even yours) and no signs of tampering anywhere. So you dismiss theory 4. You remember that you filled up the gas tank yesterday, the fuel gauge says that the tank is full, and you don't see any signs of leakage. So you can safely ignore theory 2. You notice that the lights, heater, and radio work fine, and the battery gauge indicates a fully charged battery. So you discard theory 1. When you try to start the car, you hear a clicking sound like the one you heard when the starter had failed previously. Among the theories you started with, then, theory 3 now seems the most plausible. This means that theory 5 cannot be correct since it entails two or more of the theories.

If you wanted to, you could state your argument like this:

- (1) *Your car won't start in the morning.*
- (2) *The theory that the starter has malfunctioned is the best explanation for the car's not starting in the morning.*
- (3) *Therefore, it's probable that the malfunctioning starter caused the car not to start in the morning.*

In science, where inference to the best explanation is an essential tool, usually the theories of interest are causal theories, in which events are the things to be explained and the proposed causes of the events are the explanations. Just as we do in everyday life, scientists often consider several competing theories for the same event or phenomenon. Then—through scientific testing and careful thinking—they systematically eliminate inadequate theories and eventually arrive at the one that's rightly regarded as the best of the bunch. Using this form of inference, scientists discover planets, viruses, cures, subatomic particles, black holes—and many things that can't even be directly observed.

And then there are all those other professionals who rely on inference to the best explanation. Physicians use it to pinpoint the cause of multiple symptoms in patients. Police detectives use it to track down lawbreakers. Judges and juries use it to determine the guilt or innocence of accused persons. And philosophers use it to assess the worth of conceptual theories.

With so many people in so many areas of inquiry using inference to the best explanation, you'd expect the world to be filled with countless theories proposed by innumerable people looking to explain all sorts of things. And so there are.



"WELL WHICH DO YOU THINK IS MORE LIKELY, YOUR PILLOW IS GROWING HAIR OR YOU'RE LOSING YOURS?"

www.CartoonStock.com

 "A superstition is a premature explanation that overstays its time."

—George Iles



FURTHER THOUGHT

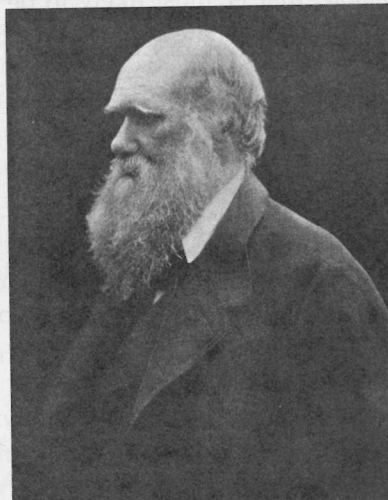
“For this, indeed, is the true source of our ignorance—the fact that our knowledge can only be finite, while our ignorance must necessarily be infinite.”

—Karl Popper

Darwin and the Best Explanation

Charles Darwin (1809–1882) offered the theory of evolution by natural selection as the best explanation for a wide variety of natural phenomena. He catalogued an extensive list of facts about nature and showed that his theory explains them well. He argued, however, that the alternative theory of the day—the view that God independently created species—does not explain them. Darwin declared:

It can hardly be supposed that a false theory would explain, in so satisfactory a manner as does the theory of natural selection, the several large classes of facts above specified. It has recently been objected that this is an unsafe method of arguing; but it is a method used in judging of the common events of life, and has often been used by the greatest natural philosophers.¹



Charles Darwin (1809–1882).

Here's a very brief table of notable or interesting proposed theories and the phenomena they are meant to explain:

Theory	To Explain . . .
Atomic	Behavior of subatomic particles
Germ	Spread of disease
HIV	Cause of AIDS
Oedipus complex	Behavior of men and boys
Placebo effect	Apparent cure of disease
The lone gunman	Assassination of John F. Kennedy
Violent video games	Violence in children
No official prayer in school	High crime and low morals
El Niño	Bad weather
El Niño	Good weather
Incumbent politicians	A bad economy
Political sex scandals	Immoral behavior of young people



FURTHER THOUGHT

Sherlock Holmes and Inference to the Best Explanation

Sherlock Holmes owed his great success as a detective primarily to inference to the best explanation. He was so good at this kind of inference that people (especially Watson) were frequently astonished at his skill. Holmes, however, was guilty of spreading some confusion about his ability. He called his method deduction, though it was clearly inductive. Holmes in action:



I knew you came from Afghanistan. From long habit the train of thoughts ran so swiftly through my mind that I arrived at the conclusion without being conscious of intermediate steps. There were such steps, however. The train of reasoning ran, "Here is a gentleman of medical type, but with the air of a military man. Clearly an army doctor, then. He has just come from the tropics, for his face is dark, and that is not the natural tint of his skin, for his wrists are fair. He has undergone hardship and sickness, as his haggard face says clearly. His left arm has been injured. He holds it in a stiff and unnatural manner. Where in the tropics would an English army doctor have seen much hardship and got his arm wounded? Clearly in Afghanistan."²

Here Holmes explains how he knew that a man had "gone about in fear of some personal attack within the last twelve-month":

"You have a very handsome stick," I answered. "By the inscription I observed that you had not had it more than a year. But you have taken some pains to bore the head of it and pour melted lead into the hole so as to make it a formidable weapon. I argued that you would not take such precautions unless you had some danger to fear."³

Of course, it's often easy to make up theories to explain things we don't understand. The harder job is sorting out good theories from bad, and that's the topic of the next few pages.



REVIEW NOTES

Minimum Requirement: Consistency

- Internal consistency: A theory that is internally consistent is free of contradictions
- External consistency: A theory that is externally consistent is consistent with the data it's supposed to explain

The work is not always easy, but there are special criteria we can use to get the job done. Before we apply these criteria, though, we have to make sure that the theory in question meets the minimum requirement of *consistency*. A theory that does not meet this minimum requirement is worthless, so there is no need to use the special criteria to evaluate the theory. A theory that meets the requirement is eligible for further consideration. Here we are concerned with both *internal* and *external* consistency. A theory that is internally consistent is consistent with itself—it's free of contradictions. A theory that is externally consistent is consistent with the data it's supposed to explain—it fully accounts for the phenomenon to be explained.

If we show that a theory contains a contradiction, we have refuted it. A theory that implies that something both is and is not the case cannot possibly be true. By exposing an internal contradiction, Galileo once refuted Aristotle's famous theory of motion, a venerable hypothesis that had stood tall for centuries. He showed that the theory implied that one falling object falls both faster and slower than another one.

If a theory is externally inconsistent, we have reason to believe that it's false. Suppose you leave your car parked on the street overnight and the next morning discover that (1) the windshield is broken, (2) there's blood on the steering wheel, and (3) there's a brick on the front seat. And let's say that your friend Charlie offers this theory to explain these facts: Someone threw a brick through your windshield. What would you think about this theory?

You would probably think that Charlie had not been paying attention. His theory accounts for the broken windshield and the brick—but not the blood on the steering wheel. You would likely toss his theory out and look for one that was complete. Like this one: A thief broke your windshield with a brick then crawled through the broken window, cutting himself in the process.

"The Universe is not obliged to conform to what we consider comfortable or plausible."

—Carl Sagan

Theories and Criteria

For a moment let's return to our example of the car that won't start. Recall that we examined five possible explanations for the non-start phenomenon:

1. The battery is dead.
2. The fuel tank is empty.



3. The starter has malfunctioned.
4. A vandal has sabotaged the car.
5. All or several of the above.

But what if someone suggested that our analysis of this problem was incomplete because we failed to consider several other possible theories that are at least as plausible as these five? Consider these, for example:

6. Each night, you are sabotaging your own car while you sleepwalk.
7. Your ninety-year-old uncle, who lives a thousand miles away from you, has secretly been going for joyrides in your car, damaging the engine.
8. A poltergeist (a noisy, mischievous ghost) has damaged the car's carburetor.
9. Yesterday, you accidentally drove the car through an alternative space-time dimension, scrambling the electrical system.

What do you think of these theories? More specifically, are the last four theories *really* at least as plausible as the first five? If you think so, *why*? If you think not, *why not*? Remember that a theory's strangeness is no good reason to discount it. It will not do to say that theories 6–9 are too weird to be true. In the history of science plenty of bizarre theories have turned out to be correct. (Quantum theory in physics, for example, is about as weird as you can get.) Earlier we concluded that theory 3 was better (more likely to be true) than 1, 2, 4, and 5. But what criteria did we use to arrive at this judgment? And on the basis of what criteria can we say that theory 3 is any better than theories 6–9? There must be *some* criteria because it is implausible that every theory is equally correct. Surely there is a difference in quality between a theory that explains rainfall by positing some natural meteorological forces and one that alleges that Donald Duck causes weather phenomena.

A simplified answer to the problem of theory choice is this: Just weigh the evidence for each theory, and the theory with the most evidence wins. As we will soon see, the amount or degree of evidence that a theory has is indeed a crucial factor—but it cannot be the sole criterion by which we assess explanations. Throughout the history of science, major theories—from the heliocentric theory of the solar system to Einstein's general theory of relativity—have never been established by empirical evidence alone.

The task of determining the best explanation has another complication. If we accept such extraordinary theories as 6–9 as legitimate possibilities, there must be no end to the number of theories that we could devise to explain the data at hand. In fact, we could come up with an infinite number of possible theories for any phenomenon simply by repeatedly adding one more element. For example, we could propose the one-poltergeist theory (a single entity causing the trouble), a two-poltergeist theory, a three-poltergeist theory, and so on.

Fortunately, despite these complications, there are reasonable criteria and reliable procedures for judging the merits of eligible theories and for arriving at a defensible judgment of which theory is best. Enter: the **criteria of adequacy**. The criteria of adequacy are the essential tools of science and have been used by scientists throughout history to uncover the best explanations for all sorts of



FURTHER THOUGHT

Inference to the Best Explanation and the External World

In Chapters 10 and 11 we will explore in detail how inference to the best explanation can be used to tackle some big issues. Here we just want to mention one of the “big questions” to which philosophers and other thinkers have applied inference to the best explanation.

A problem that has historically occupied thinkers in the history of philosophy is whether we have any good reasons to believe that there is a world outside our own thoughts. That is, is there an *external world* independent of the way we represent it to ourselves? Some people, called skeptics, have denied that we have any such good reasons because we can never get “outside our skins” to objectively compare our subjective experiences with reality. All we know is the nature of our perceptions—which may or may not be linked to the “real world” in any way.

To this puzzle many philosophers have applied inference to the best explanation. They argue that we can indeed know that there is an external reality because that belief is the best explanation of the peculiar pattern of our perceptions. In other words, the best explanation of why we seem to see a tree in front of us is that there *really is a real tree in front of us*.

events and states of affairs. Science, though, doesn’t own these criteria. They are as useful—and as used—among nonscientists as they are among men and women of science.

Applying the criteria of adequacy to a set of theories constitutes the ultimate test of a theory’s value, for *the best theory is the eligible theory that meets the criteria of adequacy better than any of its competitors*. Here, “eligible” means that the theory has already met the minimum requirement for consistency.

All of this implies that the evaluation of a particular theory is not complete until alternative, or competing, theories are considered. As we’ve seen, there is an indefinite number of theories that could be offered to explain a given set of data. The main challenge is to give a fair assessment of the relevant theories in relation to each other. To fail to somehow address the alternatives is to overlook or deny relevant evidence, to risk biased conclusions, and to court error. Such failure is probably the most common error in the appraisal of theories.

A theory judged by these criteria to be the best explanation for certain facts is worthy of our belief, and we may legitimately claim to know that such a theory is true. But the theory is not then necessarily or certainly true in the way that a sound deductive argument’s conclusion is necessarily or certainly true. Inference to the best explanation, like other forms of induction, cannot guarantee the truth of the best explanation. That is, it is not truth-preserving. The best theory



we have may actually be false. Nevertheless we would have excellent reasons for supposing our best theory to be a true theory.

The criteria of adequacy are *testability*, *fruitfulness*, *scope*, *simplicity*, and *conservatism*. Let's examine each one in detail.

Testability

Most of the theories that we encounter every day and all the theories that scientists take seriously are **testable**—*there is some way to determine whether the theories are true or false*. If a theory is untestable—if there is no possible procedure for checking its truth—then it is of little or no help in increasing our understanding. Suppose someone says that an invisible, undetectable spirit is causing your headaches. What possible test could we perform to tell if the spirit actually exists? None. So the spirit theory is entirely empty. We can assign no weight to such a claim.

Here's another way to look at it. Theories are explanations, and explanations are designed to increase our understanding of the world. But an untestable theory does not—and cannot—explain anything. It is equivalent to saying that an unknown thing with unknown properties acts in an unknown way to cause a phenomenon—which is the same thing as offering no explanation at all.

We often run into untestable theories in daily life, just as scientists sometimes encounter them in their work. Many practitioners of alternative medicine claim that health problems are caused by an imbalance in people's *chi*, an unmeasurable form of mystical energy that is said to flow through everyone. Some people say that their misfortunes are caused by God or the Devil. Others believe that certain events in their lives happen (and are inevitable) because of fate. And parents may hear their young daughter say that she did not break the lamp, but her invisible friend did.

Many theories throughout history have been untestable. Some of the more influential untestable theories include the theory of witches (some people called witches are controlled by the Devil), the moral fault theory of disease (immoral behavior causes illness), and the divine placement theory of fossils (God created geological fossils to give the false impression of an ancient Earth).



REVIEW NOTES

Criteria of Adequacy

- Testability: whether there is some way to determine if a theory is true
- Fruitfulness: the number of novel predictions made
- Scope: the amount of diverse phenomena explained
- Simplicity: the number of assumptions made
- Conservatism: how well a theory fits with existing knowledge



 "The weakness of the man who, when his theory works out into a flagrant contradiction of the facts, concludes 'So much the worse for the facts: let them be altered,' instead of 'So much the worse for my theory.'"

—George Bernard Shaw

But what does it mean for a theory to be testable or untestable? A theory is testable *if it predicts something other than what it was introduced to explain*. Suppose your electric clock stops each time you touch it. One theory to explain this event is that there is an electrical short in the clock's wiring. Another theory is that an invisible, undetectable demon causes the clock to stop. The wiring theory predicts that if the wiring is repaired, the clock will no longer shut off when touched. So it is testable—there is something that the theory predicts other than the obvious fact that the clock will stop when you touch it. But the demon theory makes no predictions about anything, *except* the obvious, the very fact that the theory was introduced to explain. It predicts that the clock will stop if you touch it, but we already know this. So our understanding is not increased, and the demon theory is untestable.

Now, if the demon theory says that the demon can be detected with x-rays, then there is something the theory predicts other than the clock's stopping when touched. You can x-ray the clock and examine the film for demon silhouettes. If the theory says that the demon can't be seen but can be heard with sensitive sound equipment, then you have a prediction, something to look for other than clock stoppage.

So other things being equal, testable theories are superior to untestable ones; they may be able to increase our understanding of a phenomenon. But an untestable theory is just an oddity.

Fruitfulness

Imagine that we have two testable theories, theory 1 and theory 2, that attempt to explain the same phenomenon. Theory 1 and theory 2 seem comparable in most respects when measured against the criteria of adequacy. Theory 1, however, successfully predicts the existence of a previously unknown entity, say, a star in an uncharted part of the sky. What would you conclude about the relative worth of these two theories?

If you thought carefully about the issue, you would probably conclude that theory 1 is the better theory—and you would be right. Other things being equal, theories that perform this way—that successfully predict previously unknown phenomena—are more credible than those that don't. They are said to be **fruitful**, to yield new insights that can open up whole new areas of research and discovery. This fruitfulness suggests that the theories are more likely to be true.

If a friend of yours is walking through a forest where she has never been before, yet she seems to be able to predict exactly what's up ahead, you would probably conclude that she possessed some kind of accurate information about the forest, such as a map. Likewise, if a theory successfully predicts some surprising state of affairs, you are likely to think that the predictions are not just lucky guesses.

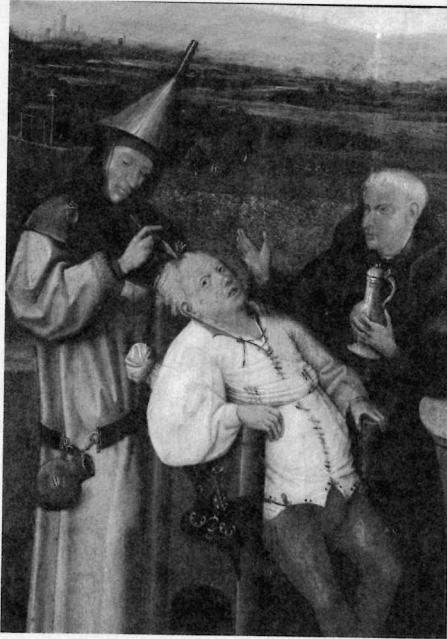
All empirical theories are testable (they predict something beyond the thing to be explained). But fruitful theories are testable and then some. They not only predict something, they predict something that no one expected. The element of surprise is hard to ignore.



FROM THE WEB

The Importance (and Fun) of Crazy Theories

Many theories proposed throughout the history of science have been, well, crazy. That is, they have been unorthodox or heretical, with a shockingly different take on the world. The heliocentric theory of our solar system is a prime example. Some of these crazy theories have turned out to be good theories—they measured up to the criteria of adequacy very well. So a crazy theory is not necessarily a bad theory. Science as a whole has always been open to offbeat explanations, but they had to be judged to have merit. Most crazy theories in science or the fringes of science, though, usually fail the criteria of adequacy miserably. The challenge for scientists and other critical thinkers is to



Trepanation: formerly for the release of evil spirits and later for the achievement of enlightenment.

remain open to unorthodox theories but not be afraid to test them through critical reasoning. Besides, offbeat theories are fun. These following theories were gleaned from the Web.

- “I personally feel that the Crystal Skulls [sculptures resembling the human skull, some of which were made by the Aztecs] are not only here to share ancient knowledge and wisdom, but to assist in awakening our race to higher spiritual laws and understanding of itself. . . . If the Crystal Skulls were not brought by extraterrestrials then certainly we must conclude their [sic] have been civilizations much more technologically or spiritually advanced than our own today.”
- “It is my belief that Mars was once a beautiful, fertile planet capable of sustaining life, much like our own, until some cataclysmic, global event changed everything. I believe that the survivors went searching for another planet, on which to live, and that they chose the Earth. We are their descendants. They were an advanced civilization who brought their technology with them. Upon reaching Earth, they proceeded to build the same type structures that were familiar to them on Mars. That way,



if there were more survivors they'd recognize the structures and know where the others were."

- "Trepanation is the practice of making a hole in the skull. It is sometimes spelled trephination. . . . trepanation was practiced on every continent through every time period and by every race of mankind until the advent of brain surgery in this century. Doctors, today, have been taught that trepanation was done in past centuries for superstitious, magical or religious reasons. They generally look on trepanation as a practice akin to blood letting. They scoff at it. . . . The risk to benefit ratio would have to have been very favorable for the practice to have been so widely practiced but official investigators haven't been able to see that there is both a rationale and a benefit to this procedure."
- "There is without any doubt whatsoever scientific evidence for the existence of the afterlife. . . . Some of the technical evidence includes: The Electronic Voice Phenomenon (Spirit Voices on Tape), Instrumental Transcommunication (two-way communication with those who crossed over), the SCOLE Experiments, Out of Body Experiences, Near Death Experiences, Empirical Materialisation, Trans and Mental Mediumship; Poltergeists, Xenoglossy and Reincarnation, the Cross-Correspondences, Proxy Sitzings."
- Have you ever dreamed of traveling in time? Now you can experience what you have only dreamed of. With the Hyper Dimensional Resonator you can travel into the past or explore the future. The world will be at your beck and call and you will have all the time in the world to explore it. . . . I sell an instrument which can be used for both, out of the body time travel and can also be used to help heal the sick."

Decades ago Einstein's theory of relativity gained a great deal of credibility by successfully predicting a phenomenon that was extraordinary and entirely novel. The theory predicts that light traveling close to massive objects (such as stars) will appear to be bent because the space around such objects is curved. The curve in space causes a curve in nearby light rays. At the time, however, the prevailing opinion was that light always travels in straight lines—no bends, no curves, no breaks. In 1919 the physicist Sir Arthur Eddington devised a way to test this prediction. He managed to take two sets of photographs of exactly the same portion of the sky—when the sun was overhead (in daylight) and when it was not (at night). He was able to get a good photo of the sky during daylight because there was a total eclipse of the sun at the time. If light rays really were bent when they passed near massive objects, then stars whose light passes near the sun should appear to be shifted slightly from their true position (as seen at night). Eddington discovered that stars near the sun did appear to have moved and that the amount of their apparent movement was just what the theory predicted. This novel

prediction then demonstrated the fruitfulness of Einstein's theory, provided a degree of confirmation for the theory, and opened up new areas of research.

So the moral is that other things being equal, fruitful theories are superior to those that aren't fruitful. Certainly many good theories make no novel predictions but are accepted nonetheless. The reason is usually that they excel in other criteria of adequacy.

Scope

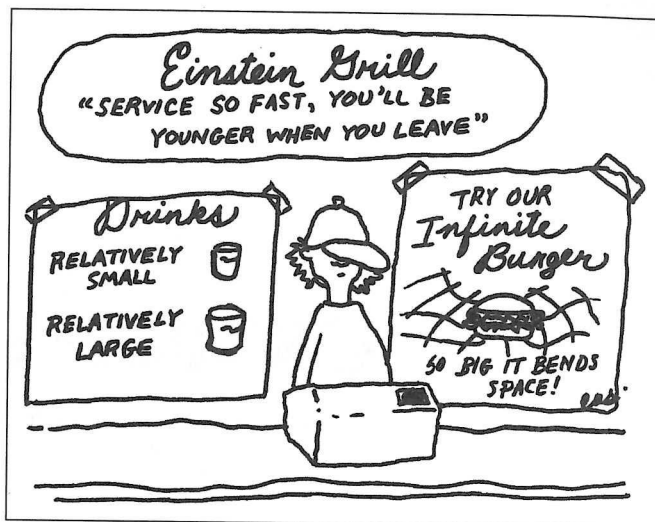
Suppose theory 1 and theory 2 are two equally plausible theories to explain phenomenon X. Theory 1 can explain X well, and so can theory 2. But theory 1 can explain or predict *only* X, whereas theory 2 can explain or predict X—as well as phenomena Y and Z. Which is the better theory?

We must conclude that theory 2 is better because it explains more diverse phenomena. That is, it has more **scope** than the other theory. The more a theory explains or predicts, the more it extends our understanding. And the more a theory explains or predicts, the less likely it is to be false because it has more evidence in its favor.

A major strength of Newton's theory of gravity and motion, for example, was that it explained more than any previous theory. Then came Einstein's theory of relativity. It could explain everything that Newton's theory could explain plus many phenomena that Newton's theory could not explain. This increased scope of Einstein's theory helped convince scientists that it was the better theory.

Here's a more down-to-earth example. For decades psychologists have known about a phenomenon called *constructive perception* (discussed in Chapter 4). In constructive perception what we perceive (see, hear, feel, etc.) is determined in part by what we expect, know, or believe. Studies have shown that when people expect to perceive a certain stimulus (say, a flashing light, a certain color or shape, a shadow), they often *do* perceive it, even if there is no stimulus present. The phenomenon of constructive perception then can be used to explain many instances in which people seem to perceive something when it is not really there or when it is actually very different from the way people think it is.

One kind of case that investigators sometimes explain as an instance of constructive perception is the UFO sighting. Many times people report seeing lights in the night sky that look to them like alien spacecraft, and they explain their perception by saying that the lights were caused by alien spacecraft. So we have two theories to explain the experience: constructive perception and UFOs from space. If these two theories differ only in the degree of scope provided by each one, however, we must conclude that the constructive-perception theory is better. (In reality, theories about incredible events usually differ on



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several criteria.) The constructive-perception theory can explain not only UFO sightings but all kinds of ordinary and extraordinary experiences—hallucinations, feelings of an unknown “presence,” misidentification of crime suspects, contradictory reports in car accidents, and more. The UFO theory, however, is (usually) designed to explain just one thing: an experience of seeing strange lights in the sky.



NEWSMAKERS

The Best Explanation for Hurricane Katrina?

Some explanations make the news in a big way. In 2008 John Hagee, a prominent evangelical leader and author, publicly endorsed the presidential candidacy of John McCain, immediately thrusting both men into a media-heightened controversy involving some of Hagee’s previously stated views. Receiving a large share of the attention was his explanation (later retracted) for the devastation of New Orleans by Hurricane Katrina:

All hurricanes are acts of God, because God controls the heavens. I believe that New Orleans had a level of sin that was offensive to God, and they were recipients of the judgment of God for that.

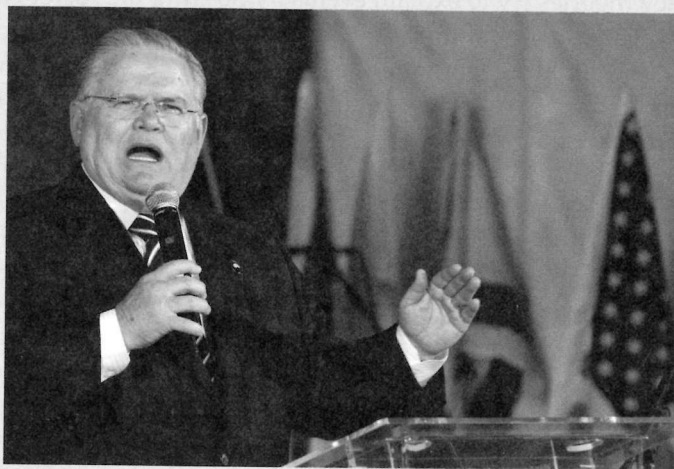
The newspaper carried the story in our local area, that was not carried nationally, that there was to be a homosexual parade there on the Monday that the Katrina came. And the promise of that parade was that it was going to reach a level of sexuality never demonstrated before in any of the other gay pride parades.

So I believe that the judgment of God is a very real thing. I know there are people who demur from that, but I believe that the Bible teaches that when you violate the law of God, that God brings





punishment sometimes before the Day of Judgment, and I believe that the Hurricane Katrina was, in fact, the judgment of God against the city of New Orleans.⁶



As an explanation for a physical phenomenon, this theory is as subject to evaluation using the criteria of adequacy as any other theory. What is the leading alternative theory to explain the natural disaster? Which theory, as judged by the criteria, is better?

Scope is often a crucial factor in a jury's evaluation of theories put forth by both the prosecution and the defense. The prosecution will have a very powerful case against the defendant if the prosecutor's theory (that the defendant did it) explains all the evidence and many other things while the defense theory (innocence) does not. The defendant would be in big trouble if the prosecutor's theory explains the blood on the defendant's shirt, the eyewitness accounts, the defendant's fingerprints on the wall, and the sudden change in his usual routine—and the innocence theory renders these facts downright mysterious.

Other things being equal, then, the best theory is the one with the greatest scope. And if other things aren't equal, a theory with superior scope doesn't necessarily win the day because it may do poorly on the other criteria—or another theory might do better.

Simplicity

Let's return one last time to the scenario about the nonstarting car. Recall that the last four theories are:

6. Each night, you are sabotaging your own car while you sleepwalk.
7. Your ninety-year-old uncle, who lives a thousand miles away from you, has secretly been going for joyrides in your car, damaging the engine.

 "I cannot help fearing that men may reach a point where they look on every new theory as a danger, every innovation as a toilsome trouble, every social advance as a first step toward revolution, and that they may absolutely refuse to move at all for fear of being carried off their feet."

—Alexis de Tocqueville



FURTHER THOUGHT

There's No Theory Like a Conspiracy Theory

Conspiracy theories try to explain events by positing the secret participation of numerous conspirators. The assassination of JFK, the terrorist attacks of 9/11, international banking, the Watergate scandal, the inner workings of the U.S. government—all these and more have been the subject of countless conspiracy theories, both elaborate and provocative. Some conspiracy theories, of course, have been found to be true after all. But most of them are implausible. The main problem with them is that they usually fail the criterion of simplicity. They would have us make numerous assumptions that raise more questions than they answer: How do the conspirators manage to keep their activities secret? How do they control all the players? Where is the evidence that all the parts of the conspiracy have come together just so?

Nonetheless, the United States seems to be Conspiracy Central. Here's a short list of things that, we are told, are the center of a massive conspiracy:

- The death of Elvis Presley
- The assassination of Martin Luther King, Jr.
- The Oklahoma City bombing
- The death of Princess Diana
- The terrorist attacks of September 11, 2001

And here are a few of the alleged cabals that are doing all the dirty deeds:

- The U.S. government
- The Vatican
- The CIA
- The Illuminati, a secret society controlling the government
- Doctors
- The Freemasons

8. A poltergeist (a noisy, mischievous ghost) has damaged the car's carburetor.
9. Yesterday, you accidentally drove the car through an alternative space-time dimension, scrambling the electrical system.

By now you probably suspect that these explanations are somehow unacceptable, and so they are. One important characteristic that they each lack is **simplicity**. Other things being equal, the best theory is the one that is the simplest—that is, the one that makes the fewest assumptions. The theory making the fewest assumptions is less likely to be false because there are fewer ways for it to go wrong.



Another way to look at it is that since a simpler theory is based on fewer assumptions, less evidence is required to support it.

Explanations 8 and 9 lack simplicity because they each must assume the existence of an unknown entity (poltergeists and another dimension that scrambles electrical circuits). Such assumptions about the existence of unknown objects, forces, and dimensions are common in occult or paranormal theories. Explanations 6 and 7 assume no new entities, but they do assume complex chains of events. This alone makes them less plausible than the simple explanation of 3, starter malfunction.

The criterion of simplicity has often been a major factor in the acceptance or rejection of important theories. For example, simplicity is an important advantage that the theory of evolution has over creationism, the theory that the world was created at once by a divine being (see Chapter 10). Creationism must assume the existence of a creator and the existence of unknown forces (supernatural forces used by the creator). But evolution does not make either of these assumptions.

Scientists eventually accepted Copernicus's theory of planetary motion (heliocentric orbits) over Ptolemy's (Earth-centered orbits) because the former was simpler (see Chapter 10). In order to account for apparent irregularities in the movement of certain planets, Ptolemy's theory had to assume that planets have extremely complex orbits (orbits within orbits). Copernicus's theory, however, had no need for so much extra baggage. His theory could account for the observational data without so many orbits-within-orbits.

Sometimes a theory's lack of simplicity is the result of constructing ad hoc hypotheses. An **ad hoc hypothesis** is one that cannot be verified independently of the phenomenon it's supposed to explain. If a theory is in trouble because it is not matching up with the observational data of the phenomenon, you might be able to rescue it by altering it—by positing additional entities or properties that can account for the data. Such tinkering is legitimate (scientists do it all the time) if there is an independent way of confirming the existence of these proposed entities and properties. But if there is no way to verify their existence, the modifications are ad hoc hypotheses. Ad hoc hypotheses always make a theory less simple—and therefore less credible.

Conservatism

What if a trusted friend told you that—believe it or not—some dogs lay eggs just as chickens do? Let's assume that your friend is being perfectly serious and believes what she is saying. Would you accept this claim about egg-laying dogs? Not likely. But why not?

Probably your main reason for rejecting such an extraordinary claim would be that it fails the criterion of **conservatism**, though you probably wouldn't state it that way. (Note: This sense of "conservatism" *has nothing to do with political parties*.) This criterion says that other things being equal, *the best theory is the one that fits best with our well-established beliefs*—that is, with beliefs backed by excellent evidence or



very good arguments. We would reject the canine-egg theory because, among other things, it conflicts with our well-founded beliefs about mammals, evolution, canine anatomy, and much more. Humans have an enormous amount of experience with dogs (scientific and otherwise), and none of it suggests that dogs can lay eggs. In fact, a great deal of what we know about dogs suggests that they *cannot* lay eggs. To accept the canine-egg theory despite its conflicting with a mountain of solid evidence would be irrational—and destructive of whatever understanding we had of the subject.

Perhaps one day we may be shocked to learn that—contrary to all expectations and overwhelming evidence—dogs do lay eggs. But given that this belief is contrary to a massive amount of credible experience, we must assign a very low probability to it.

What kind of beliefs fall into the category of “well-established” knowledge? For starters, we can count beliefs based on our own everyday observations that we have no good reasons to doubt (such as “It’s raining outside,” “The parking lot is empty,” and “The train is running late today”). We can include basic facts about the world drawn from excellent authority (“the Earth is round,” “men have walked on the moon,” and “Cairo is the capital of Egypt”). And we can include a vast array of beliefs solidly supported by scientific evidence, facts recognized as such by most scientists (“cigarettes cause lung cancer,” “vaccines prevent disease,” “dinosaurs existed,” and “germs cause infection”).

Many of our beliefs, however, cannot be regarded as well established. Among these, of course, are all those we have good reasons to doubt. But there is also a large assortment of beliefs that occupy the middle ground between those we doubt and those we have excellent reasons to believe. We may have some reasons in favor of these beliefs, but those reasons are not so strong that we can regard the beliefs as solid facts. We can only proportion our belief to the evidence and be open to the possibility that we may be wrong. Very often such claims reside in areas that are marked by controversy—politics, religion, ethics, economics, and more. Among these notions, we must walk cautiously, avoid dogmatism, and follow the evidence as best we can. We should not assume that the claims we have absorbed from our upbringing and culture are beyond question.

That being said, there are good reasons for respecting the criterion of conservatism, properly understood. We are naturally reluctant to accept explanations that conflict with what we already know, and we should be. Accepting beliefs that fly in the face of our knowledge has several risks:

1. The chances of the new belief being true are not good (because it has no evidence in its favor, while our well-established beliefs have plenty of evidence on their side).
2. The conflict of beliefs undermines our knowledge (because we cannot know something that is in doubt, and the conflict would be cause for doubt).
3. The conflict of beliefs lessens our understanding (because the new beliefs cannot be plausibly integrated into our other beliefs).

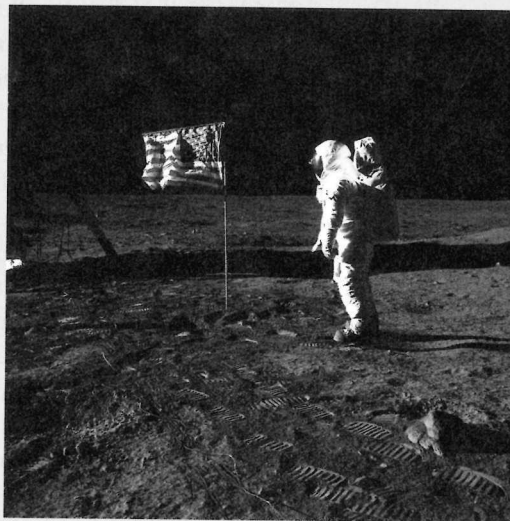


NEWSMAKERS

Was the Moon Landing a Hoax?

A stunning conspiracy theory says yes. NASA faked the whole thing, you see. Here's NASA's side of the story:

All the buzz about the Moon began on February 15th when Fox television aired a program called *Conspiracy Theory: Did We Land on the Moon?* Guests on the show argued that NASA technology in the 1960s wasn't up to the task of



a real Moon landing. Instead, anxious to win the Space Race any way it could, NASA acted out the Apollo program in movie studios. Neil Armstrong's historic first steps on another world, the rollicking Moon Buggy rides, even Al Shepard's arcing golf shot over Fra Mauro—it was all a fake! . . .

According to the show NASA was a blundering movie producer thirty years ago. For example, *Conspiracy Theory* pundits pointed out a seeming discrepancy in Apollo imagery: Pictures of astronauts transmitted from the Moon don't include stars in the dark lunar sky—an obvious production error! What happened? Did NASA film-makers forget to turn on the constellations?

Most photographers already know the answer: It's difficult to capture something very bright and something else very dim on the same piece of film—typical emulsions don't have enough "dynamic range." Astronauts striding across the bright lunar soil in their sunlit spacesuits were literally dazzling. Setting a camera with the proper exposure for a glaring spacesuit would naturally render background stars too faint to see.

Here's another one: Pictures of Apollo astronauts erecting a U.S. flag on the Moon show the flag bending and rippling. How can that be? After all, there's no breeze on the Moon. . . .

Not every waving flag needs a breeze—at least not in space. When astronauts were planting the flagpole they rotated it back and forth to better penetrate the lunar soil (anyone who's set a blunt tent-post will know how this works). So of course the flag waved! Unfurling a piece of



rolled-up cloth with stored angular momentum will naturally result in waves and ripples—no breeze required! . . .

The best rebuttal to allegations of a “Moon Hoax,” however, is common sense. Evidence that the Apollo program really happened is compelling: A dozen astronauts (laden with cameras) walked on the Moon between 1969 and 1972. Nine of them are still alive and can testify to their experience. They didn’t return from the Moon empty-handed, either. Just as Columbus carried a few hundred natives back to Spain as evidence of his trip to the New World, Apollo astronauts brought 841 pounds of Moon rock home to Earth.

“Moon rocks are absolutely unique,” says Dr. David McKay, Chief Scientist for Planetary Science and Exploration at NASA’s Johnson Space Center (JSC). McKay is a member of the group that oversees the Lunar Sample Laboratory Facility at JSC where most of the Moon rocks are stored. “They differ from Earth rocks in many respects,” he added.

“For example,” explains Dr. Marc Norman, a lunar geologist at the University of Tasmania, “lunar samples have almost no water trapped in their crystal structure, and common substances such as clay minerals that are ubiquitous on Earth are totally absent in Moon rocks.”

“We’ve found particles of fresh glass in Moon rocks that were produced by explosive volcanic activity and by meteorite impacts over 3 billion years ago,” added Norman. “The presence of water on Earth rapidly breaks down such volcanic glass in only a few million years. These rocks must have come from the Moon!”⁷

So everything considered, the more conservative a theory is, the more plausible it is.⁸

Here’s another example. Let’s say that someone claims to have built a perpetual motion machine. A perpetual motion machine is supposed to function without ever stopping and without requiring any energy input from outside the machine; it is designed to continuously supply its own energy.

Now, this is an intriguing idea—that we shouldn’t take too seriously. The problem is that the notion of a perpetual motion machine is not conservative at all. It conflicts with a very well-established belief—namely, one of the scientific laws of thermodynamics. The law of conservation of mass-energy says that mass-energy cannot be created or destroyed. A perpetual motion machine, though, would have to create energy out of nothing. Like any law of nature, however, the law of conservation of mass-energy is supported by a vast amount of empirical evidence. We must conclude, then, that it is extremely unlikely that anyone could escape the law of conservation of mass-energy through the use of any machine. (This fact, however, has not stopped countless optimistic inventors from claiming that they’ve invented such devices. When the devices are put to the test, they invariably fail to perform as advertised.)



It's possible, of course, that a new theory that conflicts with what we know could turn out to be right and a more conservative theory wrong. But we would need good reasons to show that the new theory was correct before we would be justified in tossing out the old theory and bringing in the new.

Science looks for conservative theories, but it still sometimes embraces theories that are departures (sometimes *radical* departures) from the well-worn, accepted explanations. When this dramatic change happens, it's frequently because other criteria of adequacy outweigh conservatism. We'll explore the creation and evaluation of scientific theories in the next chapter.

Occult or paranormal theories often run afoul of the criterion of conservatism. Take *dowsing*, for instance. Dowsing is the practice of detecting underground water by using a Y-shaped stick (known as a divining rod or dowsing rod), a pendulum, or another device. It's a folk tradition that's hundreds of years old. Dowser claim to be able to detect the presence of underground water by walking over a given terrain and holding the two branches of the dowsing rod (one in each hand) with its point facing skyward away from the body. (This claim, as it turns out, is unsupported.) When the point of the rod dips toward the ground, that's supposed to indicate that water is beneath the dowser. It seems to the dowser (and sometimes to observers) that the rod moves on its own, as though under the influence of some hidden force.

One theory to account for the rod's movements is this: an unknown form of radiation emanating from the underground water pulls on the diving rod, causing it to move. (A well-supported alternative theory is that the movement of the divining rod in the dowser's hands is caused by suggestion and unconscious muscular activity in the dowser.) As it stands, the radiation theory is not testable, fruitful, or simple. But its major failing is its lack of conservatism. The claim about the strange, occult radiation conflicts with what scientists know about energy, radiation, and human sensory systems. It is possible that the dowser's radiation exists, but there is no reason to believe that it does and good reason to doubt it.

We will look at many more examples shortly, but before we go any further, you need to fully understand two crucial points about the nature of theory appraisal.

First, there is no strict formula or protocol for applying the criteria of adequacy. In deductive arguments there are rules of inference that are precise and invariable. But inference to the best explanation is a different animal. There are no precise rules for applying the criteria, no way to quantify how a theory measures up according to each criterion, and no way to rank each criterion according to



The art of dowsing. What makes the rod dip?



its importance. Sometimes we may assign more weight to the criterion of scope if the theory in question seems comparable to other theories in terms of all the remaining criteria. Other times we may weight simplicity more when considering theories that seem equally conservative or fruitful. The process of theory evaluation is not like solving a math problem—but more like diagnosing an illness or making a judicial decision. It is rational but not formulaic, and it depends on the dynamics of human judgment. The best we can do is follow some guidelines for evaluating theories generally and for applying the criteria of adequacy. Fortunately, this kind of help is usually all we need. (You'll get this kind of guidance in the following pages.)

Second, despite the lack of formula in theory assessment, the process is far from subjective or arbitrary. There are many distinctions that we successfully make every day that are not quantifiable or formulaic—but they are still objective. We cannot say exactly when day turns into night or when a person with a full head of hair becomes bald or when a puddle in the rain becomes a pond, but our distinctions between night and day or baldness and hirsuteness or puddles and ponds are clearly objective. Of course, there are cases that are not so clear-cut that give rise to reasonable disagreement among reasonable people. But there are also many instances that are manifestly unambiguous. Pretending that these states of affairs are unclear would be irrational. It would simply be incorrect to believe that broad daylight is nighttime or that a puddle is a pond.

Exercise 9.6

1. When you are trying to decide between two theories, can you just rely on evidence alone to determine which theory is better?
- * 2. In theory evaluation, what is the minimum requirement of consistency?
3. According to the text, what is a “best theory”?
4. According to the text, what are the criteria of adequacy?
5. What does it mean for a theory to be testable? fruitful? conservative?
- * 6. What does it mean to say that a theory does not have much scope?
7. According to the text, are theories that posit paranormal entities simple? If not, why not?
8. What are the risks involved in accepting a nonconservative theory?

Exercise 9.7

Following are several pairs of theories used to explain various phenomena. For each pair, determine (1) which theory is simpler and (2) which one is more conservative.

1. Phenomenon: A sudden remission of cancer in a patient.
Theories: Part of the natural cycle of the disease; the result of taking an elixir with “healing properties” unknown to science.



- * 2. Phenomenon: The survival of a group of sailors whose ship sank at sea.
Theories: Quick action by a group of magic dolphins; quick action by the Coast Guard rescue team.
- 3. Phenomenon: The winning of an election by a relatively unknown candidate.
Theories: A last-minute blitz of TV ads; the candidate's endorsement by a famous convicted murderer.
- * 4. Phenomenon: A "precognitive" dream (having one's dream come true).
Theories: Coincidence; psychic energy emanating from the dreamer.
- 5. Phenomenon: The sudden friendliness of the North Korean government toward the United States.
Theories: A big change in the leadership of the government; North Korea's realization that democratic capitalism is the way to go.
- 6. Phenomenon: The bizarre and dangerous behavior of your best friend.
Theories: An allergy attack; the result of taking LSD.
- * 7. Phenomenon: A hurricane hitting south Florida.
Theories: El Niño; radiation from outer space.
- 8. Phenomenon: A huge drop in the incidence of childhood disease over the last fifty years.
Theories: Mandatory immunization; lower levels of air pollution.

Telling Good Theories from Bad.

Many (perhaps most) explanatory theories that you run into every day are easy to assess. They are clearly the best (or not the best) explanations for the facts at hand. The dog barked because someone approached the house. Your friend blushed because he was embarrassed. The senator resigned because of a scandal. In such cases, you may make inferences to the best explanation (using some or all of the criteria of adequacy) without any deep reflection. But at other times, you may need and want to be more deliberate, to think more carefully about which explanation is really best. In either case, it helps to have a set of guidelines that tells you how your inquiry *should* proceed if you're to make cogent inferences. Here, then, is the **TEST formula**, four steps to finding the best explanation:

"For any scientific theory is born into a life of fierce competition, a jungle red in tooth and claw. Only the successful theories survive—the ones which in fact latched on to the actual regularities in nature."

—Bas Van Fraassen

Step 1. State the Theory and check for consistency.

Step 2. Assess the Evidence for the theory.

Step 3. Scrutinize alternative theories.

Step 4. Test the theories with the criteria of adequacy.

(In the next chapter, you will see that this formula is also one way of describing the general approach used in science to evaluate sets of theories.)

Step 1. State the theory and check for consistency. Before you can evaluate an explanatory theory, you must express it in a statement that's as clear and specific



as possible. Once you do this, you can check to see if the theory meets the minimum requirement for consistency. If it fails the consistency test, you can have no good grounds for believing that it's correct. And, obviously, if the theory fails step 1, there's no reason to go to step 2.

Step 2. Assess the evidence for the theory. To critically evaluate any theory, you must understand any reasons in its favor—the empirical evidence or logical arguments that may support or undermine it. Essentially, this step involves an honest assessment of the empirical evidence relevant to the truth (or falsity) of the theory. To make this assessment, you must put to use what you already know about the credibility of sources, causal reasoning, and evidence from personal and scientific observations (topics covered in Chapters 4 and 8).

In this step, you may discover that the evidence in favor of a theory is strong, weak, or nonexistent. You may find that there is good evidence that seems to count against the theory. Or you may learn that the phenomenon under investigation did not occur at all. Whatever the case, you must have the courage to face up to reality. You must be ready to admit that your favorite theory has little to recommend it.

Step 3. Scrutinize alternative theories. Inference to the best explanation will not help us very much if we aren't willing to consider alternative explanations. Simply examining the evidence relevant to an eligible theory is not enough.

Theories can often appear stronger than they really are if we don't bother to compare them with others. To take an outrageous example, consider this theory designed to explain the popularity and seeming omnipresence of an American icon: Mickey Mouse is not an animated character but a living, breathing creature that lives in Hollywood. The evidence for this explanation is the following: (1) Millions of people (mostly children) worldwide believe that Mickey is real; (2) Walt Disney (Mickey's alleged creator) always talked about Mickey as if the mouse was real; (3) millions of ads, books, movies, and TV shows portray Mickey as real; (4) it's possible that through millions of years of Earth history a biological creature with Mickey's physical characteristics could have evolved; and (5) some say that if enough people believe that Mickey is real, then—through psychic wish fulfillment or some other paranormal process—he will become real.

Now, you don't believe that Mickey is real (do you?), even in the face of reasons 1–5. But you might admit that the Mickey theory is starting to sound more plausible. And if you never hear any alternative explanations, you might eventually become a true believer. (Anthropologists can plausibly argue that various cultures have come to believe in many very unlikely phenomena and exotic deities in large part because of a *lack of alternative explanations*.)

When you do consider an alternative explanation—for example, that Mickey is an imaginary character of brilliant animation marketed relentlessly to the world—the Mickey-is-real theory looks a little silly. And once you consider the evidence for this alternative theory (for example, documentation that Walt Disney created Mickey with pen and ink and that countless marketing campaigns have been launched to promote his creation), the other explanation looks even sillier.



Step 3 requires us to have an open mind, to think outside the box, to ask if there are other ways to explain the phenomenon in question and to consider the evidence for those theories. Specifically, in this step we must conscientiously look for competing theories, *then apply both step 1 and step 2 to each one of them*. This process may leave us with many or few eligible theories to examine. In any case, it's sure to tell us something important about the strength or weakness of competing theories.

Many times the criteria of adequacy can help us do a preliminary assessment of a theory's plausibility without our surveying alternative theories. For example, a theory may do so poorly regarding a particular criterion that we can conclude that, whatever the merits of alternative explanations, the theory at hand is not very credible. Such a clear lack of credibility is often apparent when a theory is obviously neither simple nor conservative.

Skipping step 3 is an extremely common error in the evaluation of explanations of all kinds. It is a supreme example of many types of errors discussed in earlier chapters—overlooking evidence, preferring available evidence, looking only for confirming evidence, and denying the evidence.

Step 3 goes against our grain. The human tendency is to grab hold of a favorite theory—and to halt any further critical thinking right there. Our built-in bias is to seize on a theory immediately—because we find it comforting or because we just “know” it's the right one—then ignore or resist all other possibilities. The result is a greatly increased likelihood of error and delusion and a significantly decreased opportunity to achieve true understanding.

Failure to consider alternative theories is the archetypal mistake in inquiries into the paranormal or supernatural (a topic we discuss in Chapter 10). The usual pattern is this: (1) You come across an extraordinary or impressive phenomenon, (2) you can't think of a natural explanation of the facts, and (3) you conclude that the phenomenon must not be natural but paranormal or supernatural. This conclusion, however, would be unwarranted. Just because you can't think of a natural explanation doesn't mean that there isn't one. You may simply be unaware of the correct natural explanation. In the past, scientists have often been confronted with extraordinary phenomena that they couldn't explain—phenomena that were later found to have a natural explanation.

Step 4. Test the theories with the criteria of adequacy. As we've seen, simply toting up the evidence for each of the competing theories and checking to see which one gets the highest score will not do. We need to measure the plausibility of the theories using the criteria of adequacy. The criteria can help us put any applicable evidence in perspective and allow us to make a judgment about theory plausibility even when there's little or no evidence to consider.

By applying the criteria to all the competing theories, we can often accomplish several important feats. We may be able to eliminate some theories immediately, assign more weight to some than others, and distinguish between theories that at first glance seem equally strong.

The best way to learn how to do step 4, as well as steps 1–3, is by example. Watch what happens when we assess the plausibility of theories for the following two phenomena.