Premise: There wasn't a puddle until the toilet started leaking.

Conclusion: Therefore the puddle was caused by the leak in the toilet.

Premise: The puddle was caused by the leak in the toilet.

Conclusion: Therefore let's fix the toilet.

TWO KINDS OF EXPLANATIONS

Many kinds of things need explaining, and it isn't surprising that many kinds of explanations exist. Here, we briefly explain two important and common types of explanations to help you recognize and understand an explanation when you see one.

Physical Causal Explanations

How did we get this flat tire?
What caused the puddle on the floor?
Why did the rocket explode?
How come I have high blood pressure?
Why is there so much snow this year?
What caused global warming?
Why did the dinosaurs die out?

Each of these questions asks for a causal explanation of an event or phenomenon that refers to its *physical* background. "Physical" here is used in the broad sense, which includes not only the domain of the discipline of physics but also those of chemistry, geology, biology, neuroscience, and the other natural sciences.

The physical background includes the general conditions under which the event occurred—in the case of the question about the rocket, for example, the physical background includes such meteorological facts as ambient temperature, atmospheric pressure, relative humidity, and so forth. However, these general conditions are usually left unstated in an explanation if they are normal for the situation; we simply take them for granted. It's when they are unusual that they might be worth noting. For example, if we have been driving on a blisteringly hot day, we might note that as a part of our explanation of the cause of our flat tire.

More important, the physical background of an event includes whatever events we determine to be the direct or immediate cause of the phenomenon in question. But there is a complication: More than one chain of causes contributes to an event's occurrence. For example, the home run clears the right-field fence; depending on our interests and knowledge, we might focus on the chain of causation that accounts for the *bat's* arrival at the point of impact; or, if we are students of pitching, we might focus on the causal chain that accounts for the *ball's* arrival. Our interests and knowledge also determine which link in a causal chain we identify as *the* cause of an event. Whether we say the home run's direct cause was a good swing, a bad pitch, or both depends on our interests; each way of putting it can be useful for different purposes.

Likewise, under many circumstances, a short explanation of the cause of an event may suffice. How did Moore get a flat tire? "There was a nail in it" would be enough of an explanation for many purposes. But under different circumstances, a more complete explanation may be required. If the tire had been in Moore's garage rather than on his van, he might require another link in the causal chain, one that explains how the nail got into the tire.

In short, what counts as an adequate physical causal explanation depends on our circumstances and needs, as we set forth in more detail following.

Behavioral Causal Explanations

Why did the union vote to approve the contract?
Why did Borkmiser veto the bill?
Why doesn't Schwarzenegger try to balance the budget?
Why are all southern states red states?
Why are butlers paid more if they have English accents?
Why does Adrian let his kids walk all over him?
What explains the popularity of text messaging?
Why does Britney Spears get so much attention?
What causes people to fight?

These are requests for behavioral causal explanations, explanations that attempt to elucidate the causes of behavior in terms of psychology, political science, sociology, history, economics, and other behavioral and social sciences. Also included as behavioral causal explanations are explanations for behavior in terms of "commonsense psychology," that is, in terms of reasons or motives. (In some contexts, it would be appropriate to distinguish reasons from motives, and both from causes, but for this discussion we need not do so.)

Like physical causal explanations, many behavioral causal explanations provide the relevant background information and, in addition, attempt to identify the immediate or direct cause of the behavior in question. In this case, however, the causal background is of a historical nature and includes political, economic, social, or psychological factors. Which factors are important depends on our interests and knowledge; one and the same event may have different explanations at the hands of psychologists, economists, historians, and sociologists. Why was Arnold Schwarzenegger elected governor of California? An explanation might talk about voters' reaction to his predecessor's policies, his popularity as an actor, or his persona. It makes little sense to suppose there is a single correct explanation of any instance of voluntary behavior.

Because behavior is less than fully predictable—at least given current knowledge—we should expect more exceptions to generalizations about behavior than to statements about regular occurrences in nature. We should similarly anticipate that theories of the behavioral and social sciences and history will be less rigid, more qualified, more probabilistic, and sometimes more philosophical than many physical theories. It would be incorrect to automatically regard this looseness as a shortcoming of a behavioral explanation.

Unlike physical causal explanations and other behavioral explanations, explanations of behavior in terms of an agent's motives or reasons make

Real Life

Behavioral Causal Explanations

Associated Press file, 2003

North Korea's march toward acquiring nuclear weapons could instigate an arms race in the Asia-Pacific region. Japan and South Korea have the capability to enter the nuclear-weapons club but have not done so because they have had confidence in the U.S. nuclear umbrella.

This photo's caption is a behavioral causal explanation, explained in this chapter.

reference not to the past but to the future. Why did Peter leave class early? He wanted to get home in time to watch *American Idol.* Why did the union vote not to approve the contract? The contract contained provisions that members thought diminished benefits. Why is the governor asking the legislature to approve a state lottery? Because she thinks it will decrease the need for new taxes. Explanations in terms of reasons and motives are forward looking, not backward looking.

One mistake is peculiar to this type of explanation—namely, failing to see the difference between *a reason* for doing something and *a particular person's reason* for doing it. Let's take a simple example: There might be a reason for aiding homeless people, but that reason might not be any particular person's reason for helping them. We have to be clear about whether we are requesting (or giving) reasons for doing something, or whether we are requesting (or giving) some individual person's reasons for doing it. When we give a reason for doing something, we are presenting an *argument* for doing it. When we cite an individual person's reason for doing it, we are *explaining* why she or he did it.

EXPLANATORY ADEQUACY: A RELATIVE CONCEPT

When is an explanation "adequate" or "satisfactory"? When does it get the job done? Obviously, this depends *entirely* on what one is looking for. If you want to know how to set up your computer, an explanation that leaves you wondering what to do next isn't satisfactory. An explanation of what happened to a missing acquaintance might be adequate for *your* interests but not for that person's parents. Even a simple phenomenon, like a puddle of water on the bathroom floor, can be explained in various ways, and which explanation is satisfactory depends on what you are looking for. Discovering that the puddle came from a leaking toilet would be enough for you to call a plumber, but if you wanted to fix the problem yourself, you'd want to know specifically where the toilet was leaking. Learning that the leak was caused by the wax sealing ring might be all you need to know to fix the problem, but maybe not. If you are interested in preventing future problems, you might want to know what caused the ring to leak in the first place. And there are various answers to the question of what caused the ring to leak, the "explanatory adequacy" of which again depends on your needs. "It leaked because it wasn't installed right" might be adequate if your interest is whether to submit the bill to the landlord. In an unusual circumstance, you might need an explanation that drilled down to the physical properties of wax. "Explanatory adequacy" is a relative concept that depends entirely on one's needs. Other phrases used to describe explanations, such as "complete," "useful," and "satisfactory," are also relative.

Nevertheless, certain minimal conditions must be met by every explanation if it is to be useful to someone. That an explanation cannot be *self-contradictory, vague, ambiguous,* or *incompatible with established fact or theory* perhaps goes without saying. That it cannot lead to *false predictions* is almost as obvious but raises a conceptual point worth examining more closely.

The Importance of Testability

A physical causal explanation generates expectations. If a leaking toilet explains the puddle, you expect the water to be cold. You expect the floor to remain dry if you fix the leak. If the reason your head cold didn't develop was that you took Zicam, you expect head colds not to develop in the future when you take Zicam. Such expectations are really predictions about the future. If an explanation generates predictions that turn out to be false, you reject it. If in the future there is no discernible improvement in your cold symptoms upon taking Zicam, you conclude that it doesn't work. If you fix the leak in the toilet and a few days later there is another puddle on the bathroom floor, you think that your first explanation probably wasn't correct or wasn't the whole story—or that you didn't do a good job fixing the problem. We test an explanation for correctness by seeing if the predictions it generates turn out to be true.

Nontestable Explanations

It's obvious that something is wrong with an explanation that leads to false predictions. Sometimes, however, an explanation generates meaningless predictions or (and this is not quite the same thing) no predictions at all. Such an explanation is said to be nontestable. Generating meaningless predictions or none is almost as bad as generating false predictions.

For example, suppose someone says that the reason butlers who speak with English accents get paid more is that "they give off good vibes." If this explanation were correct, then we would expect there to be more good vibes in a group of butlers with English accents than in a comparison group. Alternatively, one might expect to find a higher percentage of butlers with English accents in a group of butlers with good vibes. Unfortunately, we have no idea how to measure or even identify "good vibes." So it's not that our expectations aren't borne out, but rather that we have no way of telling if they are borne out. The problem with the explanation isn't that it is incorrect but that it is meaningless.

An explanation's correctness makes a difference in how the world is. If it is correct, then the world is one way; if it isn't, then the world is different. When you hear an explanation of the cause of something, you have to ask yourself the difference between the explanation's being correct and not being correct. Imagine that Uncle Charlie blames his heart problems on a sedentary life. If it is correct to say that a sedentary life causes heart problems, you would expect more heart problems among sedentary people than among active people. You would also expect to find a disproportionate number of sedentary people among those who have heart problems. If these predictions are borne out, you conclude that the explanation could well be correct; if they are not borne out, then you arrive at the opposite conclusion. Suppose, however, that Aunt Clara thinks that Uncle Charlie's heart problems are due to sins Uncle Charlie committed in a previous life. It would be unusual for Aunt Clara to think this, but not terribly so. We do occasionally hear people explaining misfortunes by attributing them to misdeeds in earlier incarnations. What predictions are generated by Aunt Clara's theory? Well, if it is true that past-life sins cause heart problems, we would expect to find more heart problems among past-life sinners than among people who did not sin in their past lives. We would also expect to find a disproportionate number of past-life sinners among people with heart problems. Immediately, we see a problem: Who is a past-life sinner? We cannot identify them. In fact, we cannot even identify people who have *had* past lives—regardless of whether they sinned. Since more people are alive now than at any time in the past, not everyone has had a past life in human form, and there is no way of distinguishing those who did from those who did not. This problem is somewhat different from the "good vibes" problem in that "good vibes" suffers from vagueness in the way in which "has had a past life" doesn't. We aren't sure exactly what counts as a "good vibe." We understand, or think we understand, what it would be to have had a past life and in it to have sinned, but we can't tell which people fall into these categories. The problem with the past life theory is that we can't tell whether it is true, whereas the problem with the "good vibes" theory is that we don't know what its being true would look like. Neither explanation, however, generates testable predictions.

Some predictions, of course, are difficult or even impossible to test due to practical limitations. Present instruments may not be sensitive enough to make certain kinds of measurements, for example. While it may be disappointing that a hypothesis isn't testable due to practical limitations, it isn't a mark against the correctness of the hypothesis. It's when a hypothesis is untestable in principle that we should abandon it.

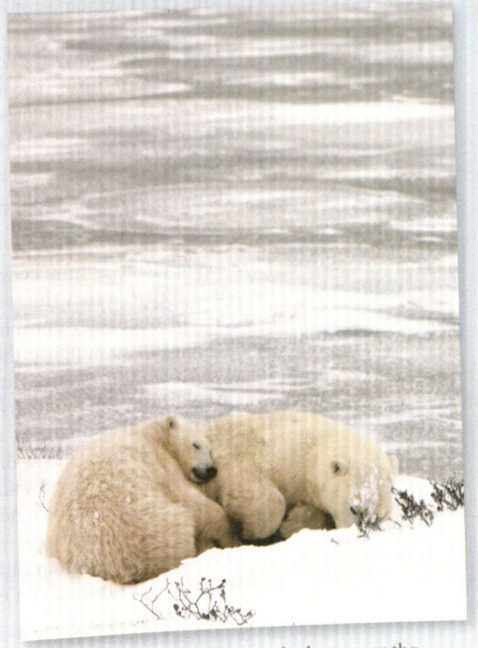
In the Media

Scientists: Warming Could Kill Two-Thirds of World's Polar Bears

"Global warming" refers to increases in average temperatures in global temperature databases over the past one hundred years. In figuring out the causes of observed global warming, among other methods scientists use computer models of the climate. They compare observed changes in the climate to changes projected from various causes by the computer models; the possible causes whose projections best match the observations provide the likeliest explanation of the observation. Think of the various possible causes (increased concentration of greenhouse gases in the atmosphere and solar variation, among others) as hypotheses that generate alternative predictions; if one hypothesis generates more accurate predictions than another, it is a likelier hypothesis.

Most predictions we read about in the newspaper—rising sea levels, melting polar ice caps, altered rainfall patterns, more violent hurricanes, and so forth—are a different kind of prediction. They are what computer models project will happen to climate in the future under various scenarios. The prediction that warming will kill the polar bears is an inference from projected reductions in sea ice and livable habitat.

The two kinds of predictions—those generated by possible explanations of a phenomenon and those generated by the phenomenon itself—are logically distinct. The hypothesis that the puddle on the bathroom floor was caused by a leaking toilet generates predictions such as that the puddle will be cold and won't recur if the toilet is fixed. Not doing something about the puddle generates a different sort of prediction, such as that the vinyl will be stained or the subflooring damaged.



A mother polar bear and her cub sleep near the ice outside Churchill, Canada, Nov. 4, 2006. Computer predictions of a dramatic decline of sea ice in regions of the Arctic are confirmed by actual observations, according to scientists for the National Oceanic and Atmospheric Administration.

Circular Explanations

A circular explanation is one that simply restates itself. "Why do butlers who speak with English accents get paid more? Because they earn more money." "Why is the floor wet? Because there is water on it." Because these explanations simply repeat that which they are supposed to be explaining, they don't generate meaningful predictions.

Unnecessary Complexity

For good reason, unnecessary complexity is considered undesirable in an explanation. It is easy to see why, if we forget about causal explanations for the moment and think of two explanations of how to do something, such as, say, build a fence. If one explanation instructs you to randomly pound nails into a piece of wood that has nothing to do with the fence, you'd be better off going with the other explanation—assuming both explanations are just as good in other respects.

In a similar way, if two *causal* explanations do an equally good job of explaining something, the least complicated explanation is preferable. An explanation that is unnecessarily complex contains elements in which there is no reason to believe. It makes assumptions that aren't really necessary. Here is an example:

> Why is there a puddle on the floor? Because both the toilet and the roof leaked.

This explanation is unnecessarily complicated.

It is *possible* that the roof and toilet both leak (in which case the example is a case of necessary complexity rather than the opposite). However, unless there is reason to suppose the leaking toilet doesn't entirely explain the puddle, it isn't necessary to assume the roof also leaks.

Explaining Uncle Charlie's health as punishment for something he did in a prior life also qualifies as unnecessarily complex. It raises difficult and entirely unnecessary questions: How did he get from the previous life to this one? Who or what is punishing Uncle Charlie? There are simpler ways of explaining Uncle Charlie's health issues.

In summary, what qualifies as an adequate explanation depends on one's needs, but at a minimum an explanation should

- be consistent
- not conflict with established fact or theory
- be testable
- not be circular
- avoid unnecessary assumptions or other unnecessary complexities

The following exercises will help you to distinguish explanations from arguments, identify physical causal explanations and behavioral causal explanations, and give you practice looking for breakdowns in explanatory adequacy.

Exercise 11-1

Which of the following state or imply cause/effect?

▲ 1. Smith's being healthy is probably what made Philadelphia more competitive this year.
2. Dress warmly! It's windy out there.
3. Gilbert's disposition has deteriorated since he and his wife separated; it isn't coincidence.

▲ 4. Senator Craig's behavior forced conservatives to call for his resignation.
5. Getting a new trumpet player certainly improved the brass sections.
6. When men wear swimsuits, they have difficulty doing math problems.
▲ 7. Despite the injuries, the Dolphins kept winning. It must have something to do with their positive attitude.
8. Too little sleep slows down your reaction time.
9. Women are worse drivers than men.
▲ 10. Why does Chaz remove the paper towels from the kitchen before his mother-in-law visits? He's a creep.
11. Randomized clinical trials produced unbiased data on the benefits of drugs.
12. The batteries in this dang flashlight are completely dead!
▲ 13. This flashlight won't work because the batteries are completely dead.
14. Believe me, the batteries in that flashlight are dead. Try it. You'll see.
15. Aunt Clara thinks her prayers cured Uncle Pete. [Caution!]
▲ 16. The risk of having a heart attack is 33 percent higher in the winter than in the summer in Philadelphia.

Exercise 11-2

What is the cause and what is the effect in each of the following?

▲ 1. The cat won't eat, so Mrs. Quibblebuck searches her mind for a reason. "Now, could it be," she muses, "that I haven't heard mice scratching around in the attic lately?" "That's the explanation," she concludes.
2. Each time one of the burglaries occurred, observers noticed a red Mustang in the vicinity. The police, of course, suspect the occupants are responsible.
3. Violette is a strong Cowboys fan. Because of her work schedule, however, she has been able to watch their games only twice this season, and they lost both times. She resolves not to watch any more. "It's bad luck," she decides.
▲ 4. Giving the little guy more water could have prevented him from getting dehydrated, said Ms. Delacruz.
5. OAXACA, Mexico (AP)—Considered by many to be Mexico's culinary capital, this city took on McDonald's and won, keeping the hamburger giant out of its colonial plaza by passing around tamales in protest.
6. Eating fish or seafood at least once a week lowers the risk of developing dementia, researchers have found.
▲ 7. It has long puzzled researchers why people cannot detect their own bad breath. One theory is that people get used to the odor.
8. Researchers based at McDuff University put thirty young male smokers on a three-month program of vigorous exercise. One year later, only 14 percent of them still smoked. An equivalent number of young male smokers who did not go through the exercise program were also checked after a year, and it was found that 60 percent still smoked. The experiment is regarded as supporting the theory that exercise helps chronic male smokers kick the habit.

9. The stronger the muscles, the greater the load they take off the joint, thus limiting damage to the cartilage, which explains why leg exercise helps prevent osteoarthritis.
10. ▲ Many judges in Oregon will not process shoplifting, trespassing, and small-claims charges. This saves the state a lot of money in court expenses.

Exercise 11-3

Divide these statements into two groups of five each, based on a distinction mentioned in this chapter.

1. ▲ The air is smoky because that house is on fire.
2. That house is on fire because the air is smoky.
3. She had a great workout because she is sweating.
4. ▲ She is sweating because she had a good workout.
5. He has indigestion because he ate something harmful.
6. He ate something harmful because he has indigestion.
7. ▲ She is late because she had car trouble.
8. She had car trouble because she is late.
9. It is late because the bars are closed.
10. ▲ The bars are closed because it is late.

Exercise 11-4

Some of the following items would normally be seen as arguments others as explanations. Sort the items into the proper categories.

1. ▲ Why am I crying? I am crying because you never remember my birthday.
2. If I were you, I wouldn't wear an outfit like that. It makes you look too old.
3. The Eagles will never make a comeback. They just don't appeal to today's younger crowd.
4. ▲ Steph won't wear outfits like that because she thinks they are tacky.
5. My toe hurts because I stubbed it.
6. The board has lost faith in the president. Why else would they ask her to resign?
7. ▲ If I were you, I wouldn't open a furniture store here, because students give away furniture every spring.
8. Most people like freestone peaches more than clingstone because they are easier to eat.
9. Around here, people don't take no for an answer. Just ask anyone.
10. ▲ Dr. York flunks people because he is a crank.

Exercise 11-5

Some of the following items would normally be seen as arguments and others as explanations. Sort the items into the proper categories.

1. ▲ Collins will probably be absent again today. She seemed pretty sick when I saw her.

2. Yes, I know Collins is sick, and I know why: She ate raw seafood.
3. Did Bobbie have a good time last night? Are you kidding? She had a great time! She stayed up all night, she had such a great time.
4. ▲ You don't think the toilet leaks? Why, just look at the water on the floor. What else could have caused it?
5. You know, it occurs to me the reason the band sounded so bad is the new director. They haven't had time to get used to her.
6. What a winter! And to think it's all just because there's a bunch of warm water off the Oregon coast.
7. ▲ Hmmm. I'm pretty sure you have the flu. If you had a cold, you wouldn't have aches and a fever. Aches and fever are a sign you have the flu.
8. Secretary Clinton goes up and down in the opinion polls. That's 'cause sometimes she makes sense, and other times she sounds crazy.
9. VIKKI: Remember the California Raisins? What happened to them?
   NIKKI: They faded. I guess people got tired of them or something.
10. ▲ Believe it or not, for a while there, a lot of young women were shaving their heads. It was probably the Britney Spears influence.
11. Couples that regard each other as equal are more likely to suffer from high blood pressure than are couples in which one perceives the other as dominant. This is an excellent reason for marrying someone you think is beneath you.
12. Couples that regard each other as equal are more likely to suffer from high blood pressure than are couples in which one perceives the other as dominant. This is apparently because couples who see their partners as an equal argue more, and that raises their blood pressure.

Exercise 11-6

Divide the following ten items into two groups, based on a distinction covered early in this chapter.

1. ▲ The reason we're so late? The car wouldn't start.
2. The reason we're so late? We wanted to visit the Simpsons.
3. The Meisters bought a new dishwasher because the old one stopped working.
4. ▲ Their dishwasher stopped working because the drain was clogged.
5. Her health problems resulted from exposure to secondhand smoke.
6. She was exposed to secondhand smoke because her parents weren't aware of the danger.
7. ▲ The planning commission approved the new subdivision because the developers enlarged lot sizes.
8. The developers enlarged lot sizes because they wanted their plans approved.
9. The tree damaged the roof by falling on it.
10. ▲ Thanks to the strong winds, the tree fell on the roof.

Exercise 11-7

Which of the following are physical causal explanations and which are behavioral causal explanations?

▲ 1. The reason the car won't start? Bad battery, I expect.
2. Why doesn't Sue like Joe anymore? She doesn't think much of his new friends.
3. We are in a recession because consumers aren't spending as much as they used to.
▲ 4. The reason consumers aren't spending as much as they used to is they are afraid the economy is getting worse.
5. Professor Snark gave a test on Friday because he wanted to surprise everyone.
6. People worship God because they are afraid of dying.
▲ 7. The hot weather we've been having is due to global warming.
8. Lightning started the fire.
9. Backpacking isn't popular these days, because people want more action in their sports.
▲ 10. The reason you can't sleep is all the coffee you drink.

Exercise 11-8

For each of the following, identify the presumed cause and the presumed effect. Then identify which items contain or imply a causal claim, hypothesis, or explanation that isn't testable. If an item falls into that category, decide whether the problem is due to vagueness, circularity, or some other problem.

▲ 1. What causes your engine to miss? Perhaps a fouled spark plug?
2. Antonio had a run of hard luck, but that's to be expected if you throw a chain letter away.
3. Petunia is grouchy because she doesn't sleep well.
▲ 4. Divine intervention can cure cancer.
5. The CIA destroyed the files because they didn't want agents identified.
6. Having someone pray for you can cure cancer.
▲ 7. Having your mother pray for you brings good luck.
8. Oatmeal lowers cholesterol.
9. Why did Claudius get the flu? Because he's susceptible to it, obviously.
▲ 10. Federer won the match mainly because Roddick couldn't return his serve.
11. Federer won the match because he wanted to win more than Roddick did.
12. The reason Tuck can play high notes so well is that he has command of the upper register.
13. Professor York's French is improving, thanks to his trips to Paris.
▲ 14. "Men are biologically weaker than women and that's why they don't live as long."

—*attributed to "a leading expert" by the* Weekly World News

15. Smoking marijuana can cause lung cancer.

Exercise 11-9

For each of the following, identify the presumed cause and the presumed effect. Then identify which items contain or imply a causal claim, hypothesis, or explanation that isn't testable. If an item falls into that category, decide whether the problem is due to vagueness, circularity, or some other problem. If you see some other problem, raise your hand and tell everybody what it is.

▲ 1. He has blue eyes because he had them in a previous incarnation.
2. The Pacers did much better in the second half. That's because they gained momentum.
3. Alcoholics can't give up drinking, because they are addicted to liquor.
▲ 4. *Gone with the Wind* was a big hit only because reviewers praised it.
5. Monfort, you want to know why you have so much bad luck? It's because you want to have bad luck. You have a subconscious desire for bad luck.
6. Why do I like Budweiser? Maybe I was subjected to subliminal advertising.
▲ 7. This part of the coast is subject to mudslides because there's a lack of mature vegetation.
8. As Internet use grew, insurance costs fell. The Internet apparently drove insurance prices down.
9. Within eleven months of September 11, 2001, eleven men connected to bioterror and germ warfare died in strange and violent circumstances. Don't tell me that's coincidence!
▲ 10. When his dog died, Hennley was so upset he could hardly eat. In my opinion, he was transferring his grief from his mother's death to his dog's.
11. Why does she sleep so late? Obviously, she's just one of those people who have a hard time waking up in the morning.
12. When parapsychologist Susan Blackmore failed to find evidence of ESP in numerous experiments, *Fate* magazine's consulting editor D. Scott Rogo explained her negative results as due to subconscious resistance to the idea that psychic phenomena exist.

—*reported in* The Skeptical Inquirer

13. According to a report in *Weekly World News*, when tourists defied an ancient curse and took rocks home from Hawaii's Volcanoes National Park, they paid the consequences. According to the report, the curse caused a Michigan man to tumble to his death falling downstairs, a Massachusetts woman to lose her savings in the stock market, and a Canadian tourist to die in a head-on car accident.
14. Why is there so much violence these days? Rap music, that's why.
15. The reason I got into so much trouble as a kid was that my father was a heavy drinker.
16. According to Martin Gardner, in Shivpuri, a village in India, there is a large stone ball weighing about 140 pounds. It is possible for five men to stand around the ball and touch the lower half with a forefinger; if they recite a prayer while doing so, the ball rises. Some believe this is a miracle of Allah.

FORMING HYPOTHESES

A statement to the effect that X causes or caused Y can be offered as a *hypothesis* rather than as a claim. A **hypothesis** is a causal explanation offered for further investigation or testing. When you hypothesize, you aren't yet stating an explanation; you are offering what you think is a likely explanation.

Often, when we are concerned with the cause of something, our reasoning falls into two parts: (1) forming a hypothesis and (2) testing the hypothesis. These are separate and distinct activities (though they involve overlapping principles). If the car won't start, we first think of possible causes; those that seem most likely we offer as hypotheses. We then test them if we can. In real life, when a car won't start, it's usually either because the battery is dead or because the cables are loose; if we find a loose cable, it seems the most likely cause, and we test this hypothesis by tightening the cable and trying to start the car.

The general strategy for arriving at the most likely hypothesis is sometimes called **Inference to the Best Explanation.** As an example, the puddle on the bathroom floor might be explained by a leaking roof, by a leaking toilet, or by somebody's having left a block of ice on the floor. But the leaking roof and melted ice theories don't explain the fact that the side of the toilet is damp; plus, perhaps, we can't see how ice could have gotten into the bathroom in the first place. In light of these considerations, we infer that the best explanation is that a leaking toilet caused the water on the floor. We then test the hypothesis by fixing the toilet and seeing what happens.

Sometimes it is difficult to find a hypothesis that explains all the facts. In the infamous O. J. Simpson murder trial, many facts seemed best explained by the hypothesis that Simpson's ex-wife, Nicole Brown Simpson, and her friend Ronald Goldman were murdered by Simpson. At the same time, a few facts seemed incompatible with this explanation and suggested an alternative hypothesis, that Simpson had been framed. The jury apparently did not think the Simpson-did-it hypothesis explained all the recalcitrant facts, and they acquitted Simpson.

Sometimes, due to practical considerations, it is difficult or impossible to definitively test a hypothesis; in such cases, we are forced to accept the hypothesis just because it is the best explanation we have. However, it is probably better to think of inference to the best explanation as a method of forming hypotheses rather than a method for confirming them.

In what follows, we shall explain four common methods used in forming hypotheses. As we shall eventually see, a rigorous application of a combination of two of them (the Method of Difference and the Method of Agreement) is used to confirm hypotheses.

The Method of Difference

Coming up with causal hypotheses requires ingenuity and clear thinking. If something unusual happens and we want to know what caused it, and if we then find that something else unusual has happened, we should suspect that as the possible cause. If you suddenly get sick after eating sushi for the first time, a reasonable hypothesis is that the sushi caused you to get sick. If the car won't start after you have been working on it, a reasonable hypothesis is that you did something that caused it not to start.

In Depth

Global Warming and Hypothesis Forming

The most widely accepted explanation of the rise in global temperatures is that it is primarily due to an increase in the concentration of greenhouse gases resulting from human activity. The greenhouse gas explanation illustrates the methodology we have been talking about in this chapter.

Speaking very generally and omitting much detail, the story goes like this. Something happens (global temperatures increase) that requires explanation. Scientists employ the Method of Difference and ask, What else is different? The greenhouse effect is well established in science and confirmed in everyday experience. Guided by this background knowledge, scientists hypothesize that the warming is due to an increase in the concentration of greenhouse-effect-producing gases. The hypothesis generates predictions, such as what data from ice cores and computer models of climate will show. These predictions do not show a perfect match with observations, but they show a better match than do projections from alternative explanations. Using the Best Diagnosis method (see page 406), that global warming is primarily due to increased concentrations of greenhouse gases becomes the best explanation of the phenomenon in question.

Following John Stuart Mill, a famous nineteenth-century English philosopher and logician, we might call this way of coming up with a causal hypothesis the **Method of Difference.** If something happens that hasn't happened in similar situations, look for some other difference between the two situations and consider whether it might not be the cause. If you wake up one morning with a splitting headache, and you remember doing something different the night before, such as reading in poor light, you should suspect it had something to do with the headache.

As mentioned above, a rigorous application of the Method of Difference in combination with the next method is used not merely to suggest a causal hypothesis but to confirm it—as you shall see in a bit.

The Method of Agreement

A correlation between two phenomena provides another good starting point for causal hypothesizing. One type of correlation is that in which occurrences of one event are accompanied by occurrences of another: The two events are said to be *associated.* If from time to time you get migraine headaches, naturally you look for something else that always precedes them. If you noticed that, say, each time you had a headache, you had eaten a bacon sandwich a few hours earlier, you'd consider the possibility that the bacon sandwich caused the headaches.

If the azaleas bloom prolifically in some years, and in other years they don't, you look for an association between the good-bloom years (or the poor-bloom years) and another phenomenon. If the good-bloom years are associated with a particular pruning technique, you suspect that as a possible cause.

According to a report in the *Journal of the American Medical Association*, infants who are breastfed have higher IQs later in life.

Maybe parents with higher IQs are more aware of the health advantages of breastfeeding and as a result are more likely to breastfeed their children.

One summer, every Saturday evening mosquitoes swarmed in the backyard of one author, making it unpleasant to be out there. What was it about Saturday evenings? What did they have in common, the author wondered? It dawned on him that he also mowed the grass late on Saturday afternoons; the association between the grass mowing and the mosquito problem suggested the hypothesis that mowing the grass stirred up the mosquitoes.

As we write this, scientists are trying to explain "colony collapse disorder"—an affliction of honeybee colonies in which bees simply fly off from their colonies and disappear forever. Are the afflicted colonies all near cellphone towers? Is the same type of pesticide used around the hives? Are the colonies near genetically altered plants? So far, no associations between abandoned hives and other possible factors have been found; but if one is, it will be plausible to suspect it as a possible cause of colony collapse. In general, when we want to find the cause of some phenomenon that has multiple occurrences, an association with some other phenomenon is a reasonable starting point for causal hypothesizing.

Another type of correlation also provides a good jumping-off point for causal hypothesizing. **Covariation** is the term for when variation in one phenomenon is accompanied by variation in another. The covariation between atmospheric CO_2 and global warming suggests a causal linkage between the two. When tobacco companies spend more money on cigarette ads, smoking rates increase. The covariation suggests that causation may be present.

We can refer to this method of generating causal hypotheses as the **Method of Agreement:** If an effect present in multiple situations is associated with or covaries with some other phenomenon, there may be a causal link between the two phenomena.*

It should be clear that causal links suggested by correlation are only *possible* links: a boy's hair gets longer as he learns the multiplication table, but there is no causal link between them. Skiing accidents increase as Christmas sales pick up, but there is no causal connection. At best, association and covariation only suggest a causal hypothesis; they don't confirm it.

In fact, thinking that a correlation or covariation between two variables *proves* that one causes the other is a mistake in logic, a fallacy that even has a Latin name: ***cum hoc, ergo propter hoc*** ("with that, therefore because of that").

The moment that declaration was made, oil prices jumped over $18 a barrel.

—*Post hoc, ergo propter hoc* from Senator Joseph Biden, criticizing a U.S. Senate resolution declaring the IRG (Iranian Revolutionary Guard) a terrorist organization.

Another infamous Latin phrase used to depict a logical fallacy is ***post hoc, ergo propter hoc*** ("after that, therefore because of that"). This mistake occurs when one thinks that the mere fact that one event *preceded* another event proves that the earlier event caused the later one. Suppose, for example, you get a headache, and the only other thing you can remember that was out of the ordinary is that you ate sushi beforehand: It is reasonable to *hypothesize* that the sushi caused the headache. But thinking that the circumstance *confirms* that the sushi caused the headache is reasoning incorrectly: *post hoc, ergo propter hoc.*

*Mill thought of the Method of Agreement as using an association between two phenomena as an indicator of causation. He spoke of the Method of Concomitant Variation as using covariation between two phenomena as an indicator of causation. We refer to both as the Method of Agreement.

Causal Mechanisms and Background Knowledge

To utilize the Method of Difference and the Method of Agreement for developing causal hypotheses, you have to use common sense and your background knowledge of what causes what and how things work. Eating sushi probably wasn't the only unusual thing that happened before you acquired a headache: On your way to the restaurant, for example, a raccoon might have crossed your path. Now, it isn't plausible to think that a raccoon crossing your path could cause a headache. Why isn't it plausible? Because, given normal experience, one cannot see *how* a raccoon crossing your path *could* cause a headache. One cannot conceive of a "causal mechanism."

The concept of a causal mechanism derives from the philosophy of science and research methodology in the social sciences, but we can describe a **causal mechanism** metaphorically as an interface between a cause and an effect—an apparatus, if you want to think of it that way—that has the property of making the effect happen, given the cause. Where there is no causal mechanism between X and Y, if Y happens after X, it is due to coincidence rather than causation.

Famously, the hemlines on women's skirts are said to covary with the stock market: As hemlines get longer, the stock market declines. Equally famously, as nonemployment decreases, the stock market declines. The idea that decreasing nonemployment could cause the stock market to *decline* is surprising but not as implausible as the idea that lengthening hemlines could cause it to decline. The latter idea is not plausible, because one cannot see how the length of hemlines *could* affect stock prices: One cannot picture a causal interface between the two things. The first hypothesis—that increasing employment causes the stock market to decline—is more plausible because one can at least imagine how this could work: Increasing employment has an inflationary effect, which in turn causes the Federal Reserve to tighten credit, which depresses the value of stocks.

In the Media

Working at Night to Be Listed as "Probable" Cause of Cancer

According to a report by Maria Cheng of the Associated Press, the World Health Organization will soon add working on overnight shifts as a probable carcinogen. That the night shift could be right there along with UV radiation and diesel exhaust fumes as a probable cause of cancer is pretty surprising. But when we think up explanatory hypotheses, we should be *guided* by our background knowledge of what causes what and how things work, not *chained* by it. (Actually, the idea that the night shift can cause cancer isn't so terribly surprising: the hormone melatonin, which can suppress tumors, is normally produced at night.)

In real life, we probably do not even begin to look for correlations as suggesting causation, except where a causal mechanism can be conceived. From our background knowledge, we can see how pesticides or cell-phone radiation might harm a bee colony; consequently, we look first for that kind of correlation rather than just any old correlation. Research indicates that people do indeed look first for plausible causal mechanisms rather than for correlations when hypothesizing about possible causes.*

What this boils down to is this: In forming causal hypotheses, in order to reduce the field of possible causes to a manageable size, one must rely on one's background knowledge about what sorts of things could cause other things. This is the way science, too, works. It builds on past understandings and doesn't start off from square one on each new occasion.

The Best Diagnosis Method

Often, finding a hypothesis is likened to assembling the pieces of a puzzle so as to create an overall picture, or solving a crime by considering clues, or—and this is our favorite analogy—diagnosing symptoms of a medical condition. You go to a physician about numbness in a leg. The doctor asks a series of questions: Exactly where in the leg is the numbness? When did it begin? Did it begin suddenly? Is it worse at some times of the day? Do you experience it in the other leg? Does it depend on your activities or the position of the leg? Have you been injured? Do you smoke? Do you have a history of high blood pressure? Are you experiencing other unusual symptoms? The doctor also considers such factors as your age, lifestyle, medical history, and the medical history of your family. The investigation discloses various symptoms (or their absence): Some of them might possibly be associated with a neurological condition, another with an orthopedic condition, perhaps another with a psychiatric condition, and so forth. The physician tries to ascertain the strongest associations and then diagnoses the patient's condition accordingly. The diagnosis is the physician's causal hypothesis. It represents the physician's idea of the best explanation of the various symptoms and other information.

Let's call this approach to forming causal hypotheses the **Best Diagnosis Method** of forming causal hypotheses, to distinguish it from the Method of Difference and the Method of Agreement. A murder has been committed, and investigators have narrowed the field to three possible suspects. Bullets from Adams's gun killed the victim, and Adams turns out to have lied about his whereabouts at the time of the murder. But Adams was a good friend of the victim, and investigators cannot discern a motive. Brady, on the other hand, owed the victim money, was known to have threatened him, and had access to Adams's gun; but he has an alibi. Cox was seen in the vicinity of the murder at the time it happened, knew the victim, and also might have had access to Adams's gun; but he has no apparent motive. As in the medical case, the investigators try to come up with the best "diagnosis" for a series of "symptoms": the diagnosis, as in the medical case described earlier, rests heavily on known or suspected associations between "symptoms" and "disease." The "disease" here is murder, and the "symptoms" are such things as being linked to the murder weapon, knowing the victim, having been seen at the crime scene, having a reason to kill the victim, lying about one's whereabouts, and so forth.

*See, for example, <http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed&uid=7720361&cmd=showdetailview&indexed=google>.

Adams exhibits some of these "symptoms," Cox and Brady exhibit others. And, when Brady's alibi collapses, the investigators move Brady's name to the top of their list of suspects.

Which diagnosis is the best? There is no abstract answer to that, except "the one that gets confirmed" (see the next section, "General Causal Claims"). But you can see that the best diagnosis is not necessarily the one that explains the most "symptoms." Symptoms vary in their importance. In forming a "diagnosis" (hypothesis) about a murder, fingerprints on the murder weapon cannot be overlooked, but lying to a policeman might be. In the murder of Nicole Brown Simpson and Ronald Goldman, a limousine driver, Allan Park, told investigators he could not contact anyone on the intercom at O. J. Simpson's gate around the time Brown and Goldman were murdered. This fact, though important, was (we assume) less important to investigators than that there was a glove outside Brown's condo with Simpson's and both victims' blood mixed on it.

As you can also see, one relies on one's background knowledge to guide one when using this method for developing causal hypotheses. Physicians will be better than most at finding the causes of medical conditions, police investigators better than most at solving crimes, and historians better than most at explaining historical events. And our own causal hypothesizing will be best in whatever areas we end up knowing best.

As a final point about the Best Diagnosis Method, you might note how it is used for developing hypotheses about everything from the cause of the universe to why the car won't start. Many of those who believe in God, for example, do so because the existence of God seems to them the best "diagnosis" for such things as love and morality, the emergence of life, the complexity and vastness of the cosmos, the seeming presence of overall design, the wording of sacred texts, apparent miracles, and so forth. At the other extreme, the car won't start, and your shift at McDonald's starts in twenty minutes. Using the Method of Difference, you look for something else that is different about the car besides the fact that it won't start. Unfortunately, as invariably happens, there is more than one "difference," more than one thing out of the norm: The car won't start, plus you heard funny clickity-click sounds when you started the car the night before, it is unusually cold out, the lights are dim, you just filled up with

On Language

The Wrong Initials Can Shorten Your Life

Researchers at the University of California, San Diego, looking at twenty-seven years of California death certificates, found that men with "indisputably positive" initials like JOY and WOW and ACE and GOD and WIN and VIP lived 4.48 years longer than a control group of men with neutral initials and ambiguous initials, like DAM and WET and RAY and SUN, that had both positive and negative interpretations. Further, men with "plainly negative" initials like ASS or DUD died on average 2.8 years earlier than did the men in the control group.

As an exercise, propose an explanation for these findings that isn't defective in terms of the criteria discussed in this chapter. Explain how you would test the explanation.

a new brand of gas, you noted a strange odor when you tried starting the car, you just installed a new battery, you started trying to charge your cell phone in the car (and it wasn't charging very well), a radio was installed the week before, and so forth. Using your understanding of how things work and what sorts of things can cause other things, you look for the correct diagnosis of the various facts: What "disease" is associated with these "symptoms"? The obvious diagnosis, of course, is that the battery is weak. Notice that some of the symptoms don't fit that diagnosis, may even conflict with it, just as some of the evidence in the Brown-Goldman murders didn't mesh with the Simpson diagnosis and just as, perhaps, some of your numbness symptoms did not quite square with the diagnosis your doctor thought was best.

Once upon a time, the authors' good friend Maureen* experienced various mysterious occurrences in her household. One morning, Maureen found an empty milk bottle on her living room floor; the next night, eerie clanging came from her garage; shortly thereafter, one of her children went into the bathroom in the middle of the night and found the bathtub mysteriously filled with water and—pillows. The eeriest occurrence was the night Maureen was awakened by the phone ringing on the nightstand. When she checked the caller ID, she found that the call had originated from her own cell phone, which was also lying on the nightstand.

Maureen thought she might need an exorcist; what she really needed was a "diagnosis" for these various "symptoms," a hypothesis that would make sense of them. Fortunately, she found one.**

The following exercises will help you recognize the Method of Difference and Method of Agreement, will give you practice understanding causal mechanisms and using your causal background knowledge, and will provide you with an opportunity to form a causal hypothesis.

Exercise 11-10

Identify each reasoning pattern as (a) the Method of Difference or (b) the Method of Agreement.

▲ 1. Pat never had trouble playing that passage before. I wonder what the problem is. It must have something to do with the piano she just bought.

2. Sometimes the fishing is pretty good here; sometimes it isn't. When I try to pin down why, it seems like the only variable is the wind. For some reason, wind keeps the fish from biting.

3. Gas prices have gone up by 40 cents a gallon in the past three weeks. It all started when they had that refinery fire down there in Texas. Must have depleted the supplies.

▲ 4. Whenever we have great roses like this, it's always been after a long period of cloudy weather. Must be they don't like direct sun.

5. All of a sudden, he's all "Let's go to Beano's for a change." Right. Am I supposed to think it's just coincidence his old girlfriend started working there?

*Not her real name.

**Maureen had been sleepwalking.

6. You really want to know what gets me and makes me be so angry? It's you! You and your stupid habit of never closing your closet door.

▲ 7. Why in heck am I so tired today? Must be all the studying I did last night. Thinking takes energy.

8. The computer isn't working again. Every time it happens, the dang kids have been playing with it. Why can't they just use the computers they have down at school?

9. What makes your dog run away from time to time? I bet it has to do with that garbage you feed him. You want him to stay home? Feed him better dog food.

▲ 10. I'll tell you what caused all these kids to take guns to school and shoot people. Every single one of them liked to play violent videogames; that's what caused it.

11. Gag! What did you do to this coffee, anyway—put Ajax in it?

12. Can you beat that? I set this battery on the garage floor last night, and this morning it was dead. I guess the old saying about cement draining a battery is still true.

▲ 13. Clinton was impeached. Then his standing went up in the opinion polls. Just goes to show: No publicity is bad publicity.

14. Why did the dog yelp? Are you serious? You'd yelp, too, if someone stomped on your foot.

15. Freddy certainly seems more at peace with himself these days. I guess psychotherapy worked for him.

16. Whenever we have people over, the next morning the bird is all squawky and grumpy. The only thing I can figure is it must not get enough sleep when we have company.

17. The mower worked fine last week, and now it won't even start. Could letting it stand out in the rain have something to do with that?

18. Every time Greg plays soccer, his foot starts hurting. It also hurts when he jogs. But when he rides his bike, he doesn't have a problem. It must be the pounding that causes the problem.

19. You know, all of a sudden she started acting cold? She didn't like it when I told her I was going to play poker with you guys.

20. Your Suburban is hard to start. Mine starts right up. You always use Chevron; I use Texaco. You'd better switch to Texaco.

Exercise 11-11

Use your understanding of what causes what and how things work to answer the following questions. There is not necessarily a correct answer, but interesting controversies may be suitable for class discussion.

▲ 1. Do any of these explanations or any combination of them seem better or worse as an explanation of why more people come down with flu in the winter? Can you think of a better explanation?

a. In winter, people wear warmer clothes.
b. Flu viruses survive longer in cold air.
c. More hot chocolate is consumed in winter.
d. People stay indoors more and are in closer proximity to one another.